PART 8

GENERAL MECHANICAL REQUIREMENTS

CONTENTS

PART 8

GENERAL MECHANICAL REQUIREMENTS

8.1 WET WELLS.....6
8.2 VERTICAL DRY PIT PUMPS.....8
8.2.1 General.....8
8.2.2 Features of Construction.....8
8.3 SUBMERSIBLE PUMPS.....10
8.3.1 General.....10
8.3.2 Features of Construction.....10
8.4 SUBMERSIBLE VERTICAL PROPELLER PUMPS.....12
8.5 CHEMICAL FEEDING EQUIPMENT.....14
8.5.1 CHEMICAL DOSING PUMPS.....14
8.5.2 CHEMICAL TANK AND MIXER.....16
8.5.3 ALUM DISPERSION FLASH MIXER.....17
8.6 INDUCTION MOTORS.....18
8.6.1 Design Requirements.....18
8.6.2 Performance and Characteristics.....18
8.6.3 Insulations.....18
8.6.4 Constructional Features.....19
8.6.5 Terminal Box.....19
8.6.6 Accessories.....19
8.6.7 Heating during Idle Period.....19
8.6.8 Earthing Pad.....20
8.6.9 Rating Plate.....20
8.6.10 Tests.....20
8.6.11 Low Voltage Motors.....20
8.6.12 HV Motor (For Process Air Blowers).....21
8.6.13 Induction Motor (Submersible Pump & mixer).....22
8.6.14 Submersible Cable.....24
8.6.15 Insulation.....25
8.6.16 Temperature Rise.....25
8.6.17 Constructional Features.....25
8.6.18 Terminal Box.....25
8.7 SLUICE GATE & WEIR GATES.....25

8.8 TRASH RACK AND SOLID GRABBING UNIT.....34
8.9 MECHANICAL COARSE BAR SCREEN-TSPS & ISPS.....39
8.9.1 General.....39
8.9.2 Frame work.....39
8.9.3 Screen bar assembly.....40
8.9.4 Rake carriage.....40
8.9.5 Rake Lifting Mechanism.....41
8.9.6 Inspection Platforms.....41
8.9.7 Dead plate.....41
8.9.8 Discharge Chute.....41
8.9.9 Covers.....41
8.9.10 Driving Mechanism.....41
8.9.11 Installation.....42
8.9.12 Gear Reducer.....42
8.9.13 Control System.....42
8.9.14 Screw Conveyor with compactor.....42
8.9.15 Portable Screenings Container.....45
8.9.16 Automatic Jam removal system.....45
8.9.17 Motors.....45
8.10 MECHANICAL FINE SCREEN-WWTP INLET.....46
8.10.1*.....*Construction features:
46
8.10.2*.....*Installation
48
8.10.3*.....*Surface Finishing:
48
8.10.4*.....*Gear Reducer
48
8.10.5*.....*Control System
49
8.10.6*.....*Controls And Instrumentation
50
8.10.7*.....*Screw Conveyor with compactor
52
8.10.8*.....*Portable Screenings Container
55
8.11 MANUAL MEDIUM BAR SCREEN FOR WWTP.....55
8.12 MANUALLY OPERATED TRAVELLING CRANE.....55
8.12.1 Crane.....55

8.12.2 Trolley and Chain Pulley Block.....56
8.13 Electrically Operated Hoists.....57
8.14 Hand Operated Hoists and Trolleys.....57
8.15 Electrically Operated Overhead Travelling Crane.....58
8.16 Jib cranes.....60
8.17.2.....COMPACT Pre-Treatment System (COMBI Unit) 61
8.18.1 Ultra Filtration System (Submerged/ Pressurized).....70
8.18 Plant Drainage Pump set.....81
8.19 Facility used for domestic water.....81
8.20 Maintenance facility using treated sewage water.....82
8.21 Fire Extinguishers.....82
8.22 Propeller Exhaust Fan.....82
8.23 Forced Fresh Air Circulation System.....83
8.24 Air-conditioning Equipment.....84
8.25 Air Hose Apparatus.....84
8.26 Surge Protection System.....84
8.27 Valves.....85
8.36.1 Electric Actuator.....86
8.36.2 Butterfly Valve.....87
8.36.3 Sluice Valve.....88
Material.....89
8.36.4 Knife Gate Valves.....89
8.36.5 Slide Gate Valve.....90
8.36.6 Non Return Valve.....91
8.36.7 Telescopic Valves.....92
8.36.8 Diaphragm Valves.....92
8.36.9 Isolating Cocks.....93
8.36.10.....Pressure / Vacuum relief valves 93
8.36.11.....Adjustable Weir Plates 93
8.36.12.....Eccentric Structure Valve 93
8.36.13.....Air Valves 94

8.28 DOMESTIC WATER PUMP SETS.....94

8.29 APPROVED VENDOR/MANUFACTURER/MAKE LIST-MECHANICAL EQUIPMENT.....95

8.30 WARRANTY.....105

8.31 PIPELINES, PIPE WORK AND FITTINGS.....105

8.40.1 Applicable codes.....105

8.40.2 Materials.....105

8.40.3 Code of Practice.....106

8.40.4 Materials for Pipelines.....106

8.40.5 Ductile Iron Pipes and Fittings.....107

8.32 REINFORCED CEMENT CONCRETE PIPES.....109

8.41.1 Design.....109

MANUFACTURING.....109

General.....109

8.41.2 Materials.....110

8.33 JOINTING.....113

General.....113

(a) Spigot and Socket joint (Rigid).....113

(b) Collar Joint (Rigid).....113

(c) Flush Joint (Internal).....113

(d) Flush Joint (External).....114

(e) Spigot and Socket (Semi-flexible).....114

(f) Collar Joint (Semi-Flexible).....114

(g) Spigot and Socket Joint (Flexible).....114

(h) Cleaning of Pipes.....114

(i) Testing at work site.....115

8.34 STEEL CYLINDER PIPES AND SPECIALS.....115

8.43.1 Design.....116

8.43.2 Manufacturing.....116

8.35 STEEL PIPE WORK.....119

(a) Welded Joints for Steel Pipes.....121

(b) Welder Performance Test.....122

(c) Testing of Welded Joints.....122

(d) Hydraulic Losses.....123

(e) Pipe work Protection.....123

(f) External protection.....124

(g) Flexibility in Pipe work.....124

(h) Puddle Flanges.....124

(i) Small Bore Pipes and Hoses....124
(j) Support of Pipe work and Accessories....125
8.36 CAST IRON PIPES....125
8.45.1 Manufacturing....125
8.37 JOINTING....128
8.38 UN PLASTICISED PVC PIPES AND FITTINGS....129
(a) Polyethylene Pipes....130
(b) Rubber Hosing....130
(c) Copper Tubes and Fittings....130
(d) Flanged Joints....130
(e) Gaskets and Joint Rings....130
(f) Flexible Couplings and Flange Adaptors....131
8.39 STORAGE & SHIPMENT....131
(a) Protection of Pipes and Fittings for Shipment....131
(b) Storage of Pipeline Materials....132
8.40 TRANSPORTATION OF PIPES AND FITTINGS....132
8.41 INSPECTION OF PIPES AND FITTINGS....132
Built-in Pipe work and other Plant....133
8.42 PIPE LAYING....133
(A) Carting & Handling....133
(B) Storage....133
8.52 LAYING....134
(A) Excavation....134
(B) Dewatering....135
(C) Special Foundation in Poor Soil....135
(D) Wooden Shoring....136
(E) Steel Plate Shoring....136
(F) Boning Staves and Sight Rails....136
(G) Laying of Pipes and Fittings/Specials....137
(H) Thrust Blocks....138
(I) Jointing....138
(J) Testing and Commissioning....138
(K) Backfilling....138
(L) Reinstatement of Road/Footpath....138
(M) Clearing of Site....138
~~**8.1 WET WELLS....7**~~
~~**8.2 VERTICAL DRY PIT PUMPS....8**~~
~~*8.2.1 General....8*~~

~~8.2.2 Features of Construction....8~~
~~**8.3 Submersible Pumps....10**~~
~~8.3.1 General....10~~
~~8.3.2 Features of Construction....11~~
~~**8.4 Submersible Vertical Propeller Pumps....12**~~
~~**8.5 Chemical Feeding Equipment....15**~~
~~**8.5.1 Chemical Dosing Pumps....15**~~
~~**8.5.2 Chemical Tank and Mixer....16**~~
~~**8.5.3 Alum Dispersion Flash Mixer....17**~~
~~**8.6 Induction Motors....18**~~
~~8.6.1 Design Requirements....18~~
~~8.6.2 Performance and Characteristics....18~~
~~8.6.3 Insulations....19~~
~~8.6.4 Constructional Features....19~~
~~8.6.5 Terminal Box....19~~
~~8.6.6 Accessories....20~~
~~8.6.7 Heating during Idle Period....20~~
~~8.6.8 Earthing Pad....20~~
~~8.6.9 Rating Plate....20~~
~~8.6.10 Tests....20~~
~~8.6.11 Low Voltage Motors....21~~
~~8.6.12 HV Motor (For Process Air Blowers)....21~~
~~8.6.13 Induction Motor (Submersible Pump & mixer)....22~~
~~8.6.14 Submersible Cable....24~~
~~8.6.15 Insulation....25~~
~~8.6.16 Temperature Rise....25~~
~~8.6.17 Constructional Features....25~~
~~8.6.18 Terminal Box....26~~
~~**8.7 Sluice Gate & Weir Gates....26**~~
~~**8.8 Trash Rack and Solid Grabbing Unit....36**~~
~~**8.9 Mechanical Coarse Bar Screen-TSPS & ISPS....41**~~
~~8.9.1 General....41~~
~~8.9.2 Frame work....42~~
~~8.9.3 Screen bar assembly....42~~
~~8.9.4 Rake carriage....42~~
~~8.9.5 Rake Lifting Mechanism....43~~
~~8.9.6 Inspection Platforms....43~~
~~8.9.7 Dead plate....43~~
~~8.9.8 Discharge Chute....43~~

8.9.9 Covers.....44
8.9.10 Driving Mechanism.....44
8.9.11 Installation.....44
8.9.12 Gear Reducer.....44
8.9.13 Control System.....44
8.9.14 Screw Conveyor with compactor.....45
8.9.15 Portable Screenings Container.....47
8.9.16 Automatic Jam removal system.....47
8.9.17 Motors.....48
8.10 Mechanical Fine Screen-WWTP Inlet.....48
8.10.1 Construction features:.....49
8.10.2 Installation.....50
8.10.3 Surface Finishing:.....51
8.10.4 Gear Reducer.....51
8.10.5 Control System.....51
8.10.6 Controls And Instrumentation.....53
8.10.7 Screw Conveyor with compactor.....55
8.10.8 Portable Screenings Container.....57
8.11 Manual Medium Bar Screen for WWTP.....57
8.12 Manually Operated Travelling Crane.....58
8.12.1 Crane.....58
8.12.2 Trolley and Chain Pulley Block.....58
8.13 Electrically Operated Hoists.....59
8.14 Hand Operated Hoists and Trolleys.....60
8.15 Electrically Operated Overhead Travelling Crane.....61
8.16 Jib cranes.....63
8.17 Grit Removing Equipment.....63
8.17.1 Vortex Grit Mechanism with Slurry (Turbo) Pump 63
8.17.2 COMPACT Pre-Treatment System (COMBI Unit) 65
A. Dual Stage Odour Control System.....74
B. Guidance for Air contaminants and quality requirements:. .76
C. Equipment Specification.....76
8.18 Aeration system with allied Equipments.....82
8.18.1 Tubular Type Diffusers.....82
8.18.2 Diffuser Assembly.....85
8.18.3 Air Header and Drop legs.....85

8.18.4 Supports and Anchors.....86
8.18.5 Spare Parts.....86
8.18.6 Installation.....86
8.18.7 Air supply Pipe Work.....86
8.18.8 High Speed Turbo Blower.....88
8.18.9 Centrifugal single stage Blower:.....90
8.18.10.....Submersible Mixer 94
8.18.11.....Rotary Air Blowers 95
8.18.12.....Acoustical Enclosure 97
8.18.13.....SBR System – General Requirements 97
8.18.14.....IFAS (Integrated Fixed film Activated Sludge) Treatment 99
8.18.15.....MBBR Treatment Technology 102
8.18.16.....Ultra Filtration System (Submerged/ Pressurized) 103
8.19 Scum removal equipment- Common for all type Technologies 114
8.20 Primary/Secondary Clarifiers.....115
8.21 Gravity Thickeners.....118
8.22 Dewatering Centrifuges.....120
8.23 Conveyor System.....122
8.24 Progressive Cavity Pumps.....123
8.25 Chlorination System.....125
8.25.1 Chlorinators.....125
8.26 Disc Filter.....136
8.27 Plant Drainage Pump set.....139
8.28 Facility used for domestic water.....140
8.29 Maintenance facility using treated sewage water.....140
8.30 Fire Extinguishers.....140
8.31 Propeller Exhaust Fan.....140
8.32 Forced Fresh Air Circulation System.....141
8.33 Air-conditioning Equipment.....142

8.34 AIR HOSE APPARATUS.....142
8.35 SURGE PROTECTION SYSTEM.....142
8.36 VALVES.....143
8.36.1 Electric Actuator.....144
8.36.2 Butterfly Valve.....145
8.36.3 Sluice Valve.....146
8.36.4 Knife Gate Valves.....147
8.36.5 Slide Gate Valve.....148
8.36.6 Non Return Valve.....149
8.36.7 Telescopic Valves.....150
8.36.8 Diaphragm Valves.....150
8.36.9 Isolating Cocks.....151
8.36.10.....Pressure / Vacuum relief valves 151
8.36.11.....Adjustable Weir Plates 151
8.36.12.....Eccentric Structure Valve 152
8.36.13.....Air Valves 152
8.37 DOMESTIC WATER PUMP SETS.....153
8.38 APPROVED VENDOR/MANUFACTURER/MAKE LIST-MECHANICAL EQUIPMENT.....153
8.39 WARRANTY.....163
8.40 PIPELINES, PIPE WORK AND FITTINGS.....163
8.40.1 Applicable codes.....163
8.40.2 Materials.....164
8.40.3 Code of Practice.....164
8.40.4 Materials for Pipelines.....164
8.40.5 Ductile Iron Pipes and Fittings.....165
8.41 REINFORCED CEMENT CONCRETE PIPES.....167
8.41.1 Design.....167
8.41.2 Materials.....168
8.42 JOINTING.....171
(a) Spigot and Socket joint (Rigid).....171
(b) Collar Joint (Rigid).....171
(c) Flush Joint (Internal).....172
(d) Flush Joint (External).....172
(e) Spigot and Socket (Semi-flexible).....172

(f) Collar Joint (Semi-Flexible)....172
(g) Spigot and Socket Joint (Flexible)....172
(h) Cleaning of Pipes....173
(i) Testing at work site....173
8.43 Steel Cylinder Pipes and Specials....174
8.43.1 Design....174
8.43.2 Manufacturing....174
8.44 Steel Pipe work....178
(a) Welded Joints for Steel Pipes....179
(b) Welder Performance Test....180
(c) Testing of Welded Joints....181
(d) Hydraulic Losses....181
(e) Pipe work Protection....181
(f) External protection....182
(g) Flexibility in Pipe work....182
(h) Puddle Flanges....182
(i) Small Bore Pipes and Hoses....182
(j) Support of Pipe work and Accessories....183
8.45 Cast Iron Pipes....183
8.45.1 Manufacturing....183
8.46 Jointing....186
8.47 Un plasticised PVC Pipes and Fittings....188
(a) Polyethylene Pipes....188
(b) Rubber Hosing....188
(c) Copper Tubes and Fittings....188
(d) Flanged Joints....188
(e) Gaskets and Joint Rings....189
(f) Flexible Couplings and Flange Adaptors....189
8.48 Storage & Shipment....189
(a) Protection of Pipes and Fittings for Shipment....189
(b) Storage of Pipeline Materials....190
8.49 Transportation of Pipes and Fittings....190
8.50 Inspection of Pipes and Fittings....191
8.51 Pipe laying....191
(a) Carting & Handling....191
(b) Storage....191
8.52 Laying....192
(a) Excavation....192
(b) Dewatering....193

~~(c) Special Foundation in Poor Soil.....193~~
~~(d) Wooden Shoring.....194~~
~~(e) Steel Plate Shoring.....194~~
~~(f) Boning Staves and Sight Rails.....194~~
~~(g) Laying of Pipes and Fittings/Specials.....195~~
~~(h) Thrust Blocks.....196~~
~~(i) Jointing.....196~~
~~(j) Testing and Commissioning.....196~~
~~(k) Backfilling.....196~~
~~(l) Reinstatement of Road/Footpath.....196~~
~~(m) Clearing of Site.....197~~

8.52 UV DISINFEC

PART 8

GENERAL MECHANICAL REQUIREMENTS

8.1 Wet Wells

(a) For the TSPS/ISPS, to prevent sewage from becoming septic, the maximum retention of sewage in the wet/suction well shall not exceed 30 minutes for the average flow in the Ultimate year.

(b) The depth of the sump shall be such that it provides at least a 15% margin over the minimum required pump submergence, calculated at the duty point on the basis of the Hydraulic Institute Standard.

(c) The wet well effective operating volume (volume between low level where all pumps are shut off and high level where all pumps except standby are operating) shall be such that the hydraulic retention time in this volume at peak flow in the ultimate year is not less than 5 minutes and the number of starts per hour does not exceed 6 for any single pump under any circumstances.

(d) Appropriate baffles shall be provided in the wet/suction well to prevent excessive turbulence and air entrainment when the material to be pumped falls freely.

(e) Benching shall be provided at the bottom of the wet well, near the suction bell mouth, to ensure that the pumps can completely drain the wet well.

(f) The wet well design shall incorporate corner fillets and ogees as appropriate to eliminate dead spots, prevent accumulation of solids or debris, and ensure the flow hydraulics ensures automatic self-cleaning of the wet well.

(g) The tops of the wet well wall, valve chamber walls, and electrical cubicle structures shall be a minimum of 750 mm above the finished ground level. No buried/ submerged structures shall be accepted for the wet well.

(h) Priming of pumps shall be ensured by providing a positive suction head.

(i) Operation of sewage pumps shall be automatic based on the sewage levels in the wet well.

(j) A standby unit of each type and size of pump employed shall be provided as specified in the mechanical requirements, and these shall be the minimum requirements.

(k) The clearance between the pump to pump outer periphery shall be not less than 1000 mm.

(l) The sequence of operation of raw sewage pumps shall be changed every 8 hours to avoid burn out of the pumps in the wet/suction well.

(m) + 5% margin on the pump capacity shall be provided for all the pumps.

(n) The total head of the pump shall be selected considering peak flow and maximum design level in the wet well for normal operating conditions and checked for satisfactory operation under extreme conditions of operation; the selected head to be revised if required.

(o) The minimum permissible velocity in the pumping mains shall be 0.6 m/sec. The maximum velocity in the pumping main shall not exceed 2 m/sec.

(p) All dry well pumping stations shall be provided with a pit and drain pumps with rigid DI piping (1 working + 1 standby) to automatically empty the stuffing box drain. All Wet well pumping stations shall be provided with a pit and drain pumps with PVC flexible piping (1 working + 1 standby) for complete draining during maintenance.

(q) Ventilation shall be provided for all the pumping stations based on 15 air changes per hour.

(r) For TSPS/ISPS, mechanical rake coarse/medium bar screen shall be provided upstream of the pumping station wet well. Provisions shall be made to allow lifting of screenings by screw conveyor.

(s) Appropriate lifting devices shall be provided for safe and easy retrieval and/or removal of the pumps from the wet well or dry well for maintenance or any other purpose at all pumping stations.

(t) On the Common header of TSPS, ISPS, Primary Sludge, RAS, Thickened Sludge, Centrifuge feed, Digester sludge and all pumping system shall be provided with a Motorized Knife Gate Valve on upstream of Flowmeter and a Swing Check Valve on downstream side.

8.2 Vertical Dry Pit Pumps

8.2.1 General

The total head capacity curve shall be continuously rising towards shut off, with the highest at shut off.

(a) Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.

(b) Pumps shall run smoothly without undue noise & vibration. Noise level shall be limited to 85 dBA at 1.86 M at sites. Vibration shall be limited to class II C of BS 4675/ zones A & B of ISO 10816. The pump set shall be suitable for starting with discharge valve open or closed. Abnormal sound and noise from the pump set and/or motor will not be acceptable.

(c) The pump set shall be capable of withstanding accidental rotation in the reverse direction.

8.2.2 Features of Construction

(a) Pump shall be centrifugal, back pullout, single stage type.

(b) Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed to allow free passage of solids. The volute tongue shall be straight across and filed to a smooth rounded edge. Casing shall be provided with wearing ring.

(c) Hand hole shall be provided in the casing to allow easy access to the impeller as well as to the casing throat. Casing drain connection with stainless steel collared plug shall be provided.

(d) Impeller shall be non-clog, enclosed type with smooth blunt edges and large waterways to allow free passage of the 50 mm size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy material.

(e) The critical speed of the rotor shall be at least 30% above the operating speed. Complete rotor shall be balanced dynamically as per ISO 9906. The pump shut-off head shall be minimum 110% and maximum 130% of the rated pump head.

(f) Replaceable shaft sleeves shall be provided and shall be securely locked or keyed to the shaft to prevent loosening. The surface hardness of the shaft sleeve shall be a minimum 400 BHN.

(g) Bearings shall be easily accessible for inspection and maintenance. The bearings shall have a minimum working life of 100,000 hours. Bearings shall be grease lubricated or non-grease type.

(h) Glands shall be fitted with suitable mechanical seals. The gland arrangement shall be designed for ease of adjustment or removal of the seal. Stuffing boxes drain with pipe connection shall be provided at the lowest point so that no leakage accumulates in it.

(i) Mechanical seals shall be provided. Grease shall be used for stuffing box sealing. Water will not be available for this purpose.

(j) The pump and motor shall be coupled through a flexible coupling. The motor shall be mounted directly on pump casing.

(k) Tapping's shall be provided at suction and discharge nozzles for pressure gauge connection. Water flushing arrangement shall be provided for cleaning of sludge pipeline at its delivery side.

(l) Impeller wear ring hardness shall be min 50 BHN higher than that of Casing wear ring.

(m) The material of construction for Centrifugal Dry Pit Pump shall be as follows:

Sr. No.	**Component**	**Material**	
		Non-clog type	**For clean water (for service water etc.)**
(i)	Impeller *	Stainless Steel: ASTM A 743 CF8M	Stainless Steel: ASTM A 743 CF8M
(ii)	Casing *	Cast Iron to BS EN: 1561 Gr EN-GJL-200	Cast Iron to BS EN: 1561 Gr EN-GJL-200
(iii)	Shaft*	Stainless Steel: BS:970 Gr 431 S29/ASTM A 276 Gr.431	Stainless Steel: BS:970 Gr 431 S29/ASTM A 276 Gr.431
(iv)	Shaft sleeve*	Stainless Steel: ASTM A 743 CA 15 Hardness 400 BHN	Stainless Steel: ASTM A 743 CA 15 Hardness 400 BHN
(v)	Casing ring*	Stainless Steel: ASTM A 743 CA 15	Stainless Steel: ASTM A 743 CA 15
(vi)	Impeller ring*	Stainless Steel: ASTM A 743 CA 15	Stainless Steel: ASTM A 743 CA 15
(vii)	Mechanical seal (Motor side and Pump side) *	oil-lubricated with tungsten carbide or silicon-carbide faces	oil-lubricated with tungsten carbide or silicon-carbide faces

* Material test certificates shall be furnished by the Contractor.

8.3 Submersible Pumps

8.3.1 General

Pumps and drives shall be rated for continuous duty and shall be capable of pumping the flow range specified in the specifications without surging, cavitations or excessive vibration to the limits specified. The pump shall meet maximum allowable shut-off head. The pumps shall not overload the motors at any point on the maximum pump speed performance characteristic curve and the pump operating range within the limits of stable pump operation. The total head capacity curve shall be continuously rising towards the shut-off as flow decreases throughout the entire curve from run out to shut-off head with the highest at shut off. Its total head capacity curve shall be continuously rising towards shut off with the highest at shut off, and its capacity shall be meet to handle sludge volume.

(a) Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.

(c) The pumps shall be designed to handle solid sizes of up to 100 mm for the raw sewage application and 50 mm for all other process fluids. Specific gravity of sewage is 1.02 and Sludge 1.05.

(d) Pumps and motors shall run smooth without undue noise and vibration, cavitations, oil or water leaks over the range of operation. To ensure vibration free operation, all rotative components of pump shall be statically and dynamically balanced to BS 6861 as per zones A&B of ISO 10816-1. Vibration levels shall not exceed the levels given in BS 4675. Abnormal sound and noise from the pump set and or motor will not be acceptable.

(f) The pump set shall be suitable for starting with the discharge valve open and/or closed.

(g) The pump set shall be capable of withstanding the accidental rotation in the reverse direction.

8.3.2 Features of Construction

(a) The pump shall be a centrifugal, vertical spindle, non-clog, wear-resistant, and single-stage type.

(b) Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed to allow free passage of solids. The volute tongue shall be filed to a smooth, rounded edge.

(c) Double Mechanical seals (back-to-back) shall be provided to protect the motor from ingress of sewage along the shaft. The preliminary and secondary seals shall be oil-lubricated with tungsten carbide or silicon carbide faces, and they shall be equipped with an electrical monitoring system for seal failure detection. Seals must be capable of withstanding rotation in either direction. A detector shall indicate when moisture is leaking past the first seal.

(d) Impeller shall be non-clog enclosed type with smooth blunt edges and large water ways so as to allow free passage of the large size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy materials.

(e) The critical speed of the rotor shall be at least 30% above the operating speed. The pump shut off head shall be minimum 110% and maximum 130% of the rated pump head.

(f) Pump-sets shall have double bearings. Bearings shall be of the anti-friction type. Bearings shall be capable of taking the static weight of the rotating parts and any thrust generated by the pump's operation. The bearing life shall be a minimum of 100,000 hrs. of operation.

(g) Each pump shall be complete with a cast iron delivery connection arrangement for fixing to the concrete floor of the suction well. The joint between the pump discharge flange and the delivery piping shall be made by merely lowering the pump into guide rails / rope from access level. It shall be provided with all necessary fixings for guiding the pumps during lifting/lowering. Each pump shall be provided with a SS 316 lifting chain conforming to BS 1663 and BS 4942.

(h) Each pump shall be provided with an automatic coupling device for attaching to the duck foot bend base at low level by using lifting chain SS 316 and guide rail SS 316, even whilst the pump is submerged, without the need for personnel to enter the well. This automatic coupling device shall easily and automatically couple and uncouple from the duck foot bend base and be complete with necessary accessories. All links and cables shall be multi-stranded stainless steel.

(i) The materials of construction for submersible pumps shall be as follows:

S. No.	Component	Material
(i)	Impeller *	Stainless Steel: ASTM A 743 CF8M
(ii)	Casing *	Cast Iron to IS:210 Gr FG 260
(iii)	Mechanical seal (Motor side and Pump side) *	oil-lubricated with tungsten carbide or silicon-carbide faces
(iv)	Shaft*	Stainless Steel: BS:970 Gr 431/420
(v)	Bush*	Bronze IS 318 Gr. LT B2
(vi)	Guide rail pipe	Stainless Steel: BS:970 Gr 316
(vii)	Lifting Chain	Stainless Steel: AISI 316
(viii)	Fasteners and Foundation Bolts	Stainless Steel AISI 316

* Material test certificates from a government-approved metallurgical laboratory shall be furnished by the Contractor.

(j) Each pump shall be tested at the manufacturer's premises for the full operating range of the pump to BS 5316 Part 1. Pump performance shall be within the tolerance limits specified in the above BS.

8.4 Submersible Vertical Propeller Pumps

Application where larger volumes must be pumped up to relatively low heads Vertical Propeller Tube Type pumps should be used. Tube shall be of SS 316 material with minimum 8 mm thick.

Design Requirements

(a) Pump

(i) Pumps shall be compact, single stage, submersible propeller, vertical shaft, wear resisting, designed to install vertically in a Stainless-steel tube with an automatic coupling, suitable for screened sewage applications.

(ii) Pumps shall be designed for continuous operation under submerged conditions as well as intermittent operation.

(iii) Pumps shall be fitted with dynamically balanced non-clog propellers designed to pass coarse solids of at least 50 mm diameter.

(iv) The equipment shall be capable of developing the required total head at rated capacity. Total head capacity curve shall be continuously rising from minimum head to maximum head.

(v) Pump operating speed shall be less than 1000 rpm.

(vi) Pumps shall run smooth without undue noise and vibration. The velocity of vibration should be within 4.5 mm/sec. The noise level should be limited to 85 dBA at a distance of 1.86 M.

(vii) Pump should be equipped with double mechanical seals. Lower sealing between Impeller and Oil chamber and upper sealing between Oil chamber and motor winding.

(b) Submersible Motor

(i) Motor should be water pressure tight encapsulated, fully flood-proof motor, 3 phase Squirrel Cage Induction Motor, 415V +/-10%, 50 Hz, with IP-68 Enclosure with Class H/F Insulation, Temperature Rise: according to class B, IE3 Premium Efficiency Motor accordance with IEC60034-30.

(ii) Water pressure sealed connection chamber, with two-stage cable entry, protected against excessive cable tension and bending. The cable shall be EPR-insulated, Double sheathed, designed and certified for permanent use in sewage water, and suitable for a conductor Temperature of 80 °C.

(iii) Motor should be of low temperature rise so that it allows for a high service factor. Minimum service factor should be 1.3. 30% safety margin against overheating when a motor is operated under full load:

- At low line voltage
- At generator sets, which are slightly over speeding.
- In a medium with a temporarily higher temperature.

(iv) The propeller pump pumps the liquid upward in the steel pipe, which then flows around the motor. With this action, motor cooling happens automatically.

(v) All Motors shall be compatible with VFD operation.

(vi) The installed power rating of the motor should be larger than 115% of the power required at the duty point.

(vii) Bi-metallic thermal sensors should be provided in each phase of the motor winding and both bearings (upper and lower) to monitor temperature rises in the motor windings and bearings. The sensors shall be connected in

series and shall be coupled to the motor contactor coil such that anyone-switch opening will shut down the motor.

(viii) Moisture sensors should be provided in the motor housing, mechanical seal oil bath & connection chamber of the motor. Moisture Sensors with an electronic amplifier trip the Motor in case of ingress of water.

i. For Oil chamber - To detect the Mechanical Seal Failures.
ii. For Motor housing - To monitor leaks in Motor housing.
iii. For Connection Chamber - To detect failure through Cable entry.
iv. Mating surfaces shall be watertight and fitted with nitrile O-rings.

(c) Features of Construction

The pump should be a Vertical Shaft, wear-resistant, single-stage, submersible Propeller type, suitable for screened sewage applications.

Pumps should be identical and suitable for parallel operation with equal load division. Components of identical pumps should be interchangeable.

Pump casing should be of robust construction. Liquid passages should be finished smooth and designed so as to allow free passage of solids as specified below.

Axial propeller with 3 or 4 propeller blades and diffuser on discharge side. Pumps should be provided with anti-friction ball or roller type bearings, lubricated-for life, maintenance-free designed for a L10 bearing life of 100,000 hours at BEP and shall be of enough size to transfer all radial and axial loads to the pump housing and minimize shaft deflection. Maximum shaft deflection should be 0.05 mm at mechanical seal face.

Pump should be furnished complete with coupling ring for welding in the steel pipe to hold the pump in steel tube, Lifting chain, Power & Control Cable, Motor control system, control panel and level switches.

For lifting the pump, a Stainless Steel Lifting hoop/handle should be fitted on the motor top.

All mating surfaces of the pump and motor shall be machined and fitted only with O-rings (NBR) where watertight sealing is required.

The pump should be equipped with double mechanical seals. Lower sealing by means of a SIC/SIC between Impeller and Oil chamber, and upper sealing by SIC/SIC mechanical seal between Oil chamber and motor winding, independent of the direction of rotation.

The propeller and the Rotor shaft should be dynamically balanced.

The Pump set shall be capable of withstanding the accidental rotation in the reverse direction.

Description	**Material of Construction**
Cooling/oil chamber, Connection chamber, Motor housing, Diffuser / Inlet Diffuser	CI IS 210 Gr. FG.260
Shaft	Stainless Steel AISI 431/420
Propeller Blades	SS ASTM A 743 Gr.CF8M
O-ring/Seals	Nitrile rubber (NBR)
Fasteners	SS 316
Lifting Chain	SS 316

8.5 Chemical Feeding Equipment

8.5.1 Chemical Dosing Pumps

(a) Chemical dosing pumps shall be of the piston diaphragm or mechanical diaphragm type as specified. Pumps may be arranged in simplex or duplex arrangements to suit the capacity or process requirements. The pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute (spm). Pump, motor and driving arrangement shall be mounted on a robust combined baseplate.

(b) Pump liquid ends shall be selected for compatibility with the pumped liquid. Suction and discharge valves shall be the single ball type allowing a free flow self-cleaning action. Ball and seat materials shall be resistant to abrasion.

(c) Pumps shall incorporate a variable stroke mechanism to allow the output to be varied while the pump is running. Stroke adjustment shall be manual or, where specified, by an electrical or pneumatically controlled stroke positioner. A stroke length indicator and digital stroke counter shall be fitted. Pumps shall be driven by a flange-mounted IP55 motor, via an oil-bath reduction gearbox and a variable stroke mechanism, providing stepless adjustment between zero and maximum stroke length. Where flow

proportional dosing is required the variation of output shall be achieved by varying the speed of the pump motor and not the pump stroke length.

(d) The normal operating range of the dosing pump shall be not less than 6:1.

a. Mechanical Diaphragm: Diaphragm rigidly coupled to the drive train. Single suction Pumps and discharge valves. Glandless. Accuracy: ± 3% of stroke.

b. Piston Pumps : Cylinder and piston with packed gland. Double-suction and discharge valves can be fitted for greater accuracy at high pressures. Accuracy: ± 1% of stroke.

c. Piston Diaphragm Pumps: Diaphragm hydraulically operated by liquid displaced by a plunger and protected from excess pressure via a relief valve. Accuracy: ± 2% of stroke.

Materials shall be selected to suit the chemicals being pumped. Liquid ends shall be polypropylene, 316 stainless steel, glass, or Hastelloy C. Diaphragm materials shall be butyl rubber, PTFE, or Hypalon and glands shall be PTFE or Neoprene.

(e) Each pump shall be provided with inlet and outlet isolating valves and with pressure relief and non-return valves. On the suction side, a Y-type strainer shall be provided for each pump set. Dosing pumps shall be provided with back pressure loading valves and pulsation dampeners in the delivery lines.

(f) A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe can be shut off or where pressure may rise to an excessive point. The relief valve shall be sized to handle the system pressure and to discharge maximum pump output freely and shall be located in the discharge line between the pump and the first downstream isolating valve or in the case of dosing pumps the back pressure loading valve. Relief valves when used on pumps handling non-hazardous chemicals shall discharge the vented liquid to waste. When used on hazardous chemicals the valve outlet shall be piped back to the suction supply tank or bunded area. The open end of the return pipe shall be located in a visible position, allowing for the detection of any relief valve leakage or operation. Pump transferring/dosing chemicals to systems under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release of air where necessary.

(g) Unless otherwise specified flushing connections shall be provided at each pump inlet and flushing shall be manual. When flushing, water shall be

discharged either locally through a drain valve or to the point of application of the chemical. Facilities shall also be provided for flushing chemical pump suction and delivery manifolds and delivery lines to point of application.

(h) Dosing pumps and motors shall preferably incorporate an integral reduction gearbox drive that is totally enclosed, and oil-bath lubricated. The gearbox shall incorporate cams for the diaphragm drive and shall be equipped with filling and drain connections, as well as a visible oil level indication.

(i) All dosing pumps shall have facilities/terminals for pulse input and output (4-20 mA) to facilitate online control via the plant's PLC and SCADA.

8.5.2 Chemical Tank and Mixer

(i) General

This tank shall be used to dissolve the alum or polymer to a constant concentration and feed the solution to the outlet channel of the aeration tank or the dewatering equipment. It shall be a vertical tank and shall be composed of tank main body, mixer, manhole, electrical level gauges, direct reading level gage, ladder, air exhaust pipe etc.

(ii) Fabrication

(a) The tank shall be made of corrosion-resistant material.

(b) The tank shall be provided with a removable cover to prevent chemical scattering, and also with a vent pipe.

(c) The tank shall be provided with necessary mounting seats for the overflow pipe, the drain pipe to the nearest drain point, etc.

(d) The motor-driven mixer shall be a vertical speed reducer, a direct-coupled type of 2-stage propeller type, as a rule, and shall be constructed to endure continuous operation free from vibration, etc. The mixer shall be at the centre or at a position off the centre according as the tank being angular or circular.

(e) The mixer shall be protected by electrical prevention of dry operation and controlled by timer.

(f) The tank shall be constructed to seal gas and splash from below at the area where the mixer shaft drive portion passes through.

(g) Alum feed cage of stainless steel shall be provided inside the alum solution tank.

(iii) Materials

(a) Main Tank body : GRP/HDPE
(b) Mixer frame : SS316
(c) Mixer shaft : SS316
(d) Blade : SS316L

(iv) Accessories (per Unit)

(a) Foundation bolt and nut x 1 set
(b) Air vent pipe x 1 set
(c) Mixer x 1 unit
(d) Direct reading level gauge x 1 unit

8.5.3 Alum Dispersion Flash Mixer

The flocculant injection facility shall be constructed to inject the flocculant into the outlet side of the A2O aerobic tanks to reduce the phosphorus in the treated wastewater.

The location where flocculant is injected should consider the contact time required for effective phosphorus removal.

- Consider that the injection method shall be appropriately injected according to the type and properties of the flocculant used.
- The flocculant shall be selected in consideration of the effect on nitrifying bacteria.
- The flocculant injection facility shall be equipped with an overturn prevention and automatic control device.
- The injection volume should remain stable from the maximum to the minimum injection volume.
- Chemical storage tanks, dissolution tanks, and mixers shall be made with corrosion-resistant materials.
- The capacity of the chemical storage tank and the capacity of the dissolution tank shall be considered for work efficiency.
- For the infusion pump, select a model that can inject stably and is corrosion resistant.
- Injection pumps shall be selected that are easy to maintain.
- The injection pumps and dissolution mixers should be linked to the water level gauge in the chemical tank to prevent operation when the tank is empty.
- Water facilities shall be provided for dissolving chemicals.
- The injection piping shall be selected from materials that can withstand corrosion and injection pressure.

- The injection equipment shall be equipped with an electromagnetic flow meter, pressure reducing valves, strainers, check valves, pressure gauge, diaphragm valves, bypass valves and drain valves.
- A water washing pipeline shall be installed in the chemical injection piping.
- Concrete breakwater shall be installed around the chemical storage tanks.
- Drain pits, drainage pumps, cleaning water piping equipment, and ventilation equipment shall be provided in the chemical injection room.
- Platforms, stairs, and handrails shall be made of corrosion-resistant materials.
- The mixing chambers shall be of reinforced concrete. The inlet to the mixing chambers shall be designed to provide an equal distribution to each unit. The outlets of mixing chambers leading to the secondary clarifier shall be provided with electrically operated sluice gates. The freeboard shall be at least 50 cm.
- A flash mixer shall be used to intimately mix the Alum and the aerated sewage as rapidly as possible. One flash mixer shall be provided for every unit located before the flow is split to the secondary clarifier distribution chamber.
- The flash mixer shall be a stirred tank constructed from reinforced concrete, rectangular in cross-section. Each Chamber shall be connected to the drainage system by means of pipe and gate valve.
- The flash mixer design shall be such that short-circuiting is minimized and the coagulant is thoroughly mixed with the water at the outlet of the flash mixer.
- The mechanical equipment for flash mixers shall comprise stainless steel (SS-316L) agitating paddles fixed on stainless steel (SS-316) shaft with thrust bearing support, driving gear consisting of a motor coupled to a reduction gear of appropriate ratio.
- The motor and gearbox arrangement shall be covered and any spillage of oil from the gearbox shall be prevented from entering the aerated sewage.
- The Flash Mixer installation area shall be provided with Monorail and Hoists facility for handling of the Flash Mixers and the accessories.

8.6 Induction Motors

8.6.1 Design Requirements

The motors shall be suitable for operating on a 415 V, 50 Hz, 3 phase, Ac supply.

The motors shall generally conform to IS: 325 or relevant equivalent internationally approved standards. Additionally, the specific requirements mentioned in the following clauses shall also be met. All motors shall be IE 3 energy efficient type.

8.6.2 Performance and Characteristics

(a) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:

(i) Variation in supply voltage ± 10%
(ii) Variation in supply frequency ± 5%
(iii) Combined voltage and frequency variation ±10%

(b) Motors shall be suitable for full voltage direct-on-line starting or star delta starting. Minimum permissible starting voltage shall be 85% of the rated voltage.

(c) The Power rating of the motor shall be the larger of the following:

(i) 115% of the power input to the pump at the duty point at a speed corresponding to the frequency of 50 Hz.
(ii) Maximum power input while operating single pump corresponding to the speed of 50 Hz.

8.6.3 Insulations

Any joints in the motor insulation such as at coil connections or between slot and winding sections, shall have strength equivalent to that of slot sections of the coil. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The motors shall be provided with class F insulation with temperature rise limited to that of class B insulation. The degree of enclosure protection of motors shall be of minimum IP 55.

Motors shall be given power house treatment. This comprises an additional treatment to the winding over and above the normal specified treatment. After the coils are placed in slots and all connections have been made, the entire motor assembly shall be impregnated by completely submerging in a suitable insulating compound or varnish followed by proper baking. At least three such submersions and backings shall be applied to the assembly.

8.6.4 Constructional Features

The motor construction shall be suitable for easy disassembly and reassembly. The enclosure shall be sturdy and shall permit easy removal of any part of the motor for inspection and repair.

a) Motors weighing more than 25 kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.
b) The rotor bars shall not be insulated in the slot portion between the iron core laminations for squirrel cage motors.

8.6.5 Terminal Box

Terminal boxes shall be of weather proof construction designed for outdoor service. To eliminate entry to dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame. It shall be suitable for bottom entry of cables. It shall be capable of being turned through 360 degrees in steps of 90 degrees.

The terminals shall be of the stud type with necessary plain washers, spring washers and check-nuts.
They shall be designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearances. Suitable cable glands and cable lugs shall be supplied to match specified cables.

Separate terminal boxes shall be provided for the following:
(i) Starter leads; and
(ii) Space heater

8.6.6 Accessories

Two independent earthing points shall be provided on opposite sides of the motor, for bolted connections. These earthing points shall be in addition to the earthing stud provided in the terminal box.

8.6.7 Heating during Idle Period

For motors rated below 7.5 kW, during idle periods, the stator winding will be connected to a required single phase, 50 Hz, AC supply for heating and elimination of moisture. The supply will be connected between any two terminals.

Motors rated 7.5 kW and above shall have space heaters suitable for 230V, single phase, 50 Hz, AC supply. Space heaters shall have adequate capacity to maintain motor internal temperature above the dew point to prevent moisture condensation during the idle period. The space heaters shall be placed in easily accessible positions in the lowest part of the motor frame.

8.6.8 Earthing Pad

Two independent earthing pads of non-corrodible metal shall be welded or brazed at two locations on opposite sides, complete with suitable bolts and washers for earthing. These earthing pads shall be in addition to earthing stud provided in the terminal box.

8.6.9 Rating Plate

The following details, in addition to those specified in applicable standards shall be included on the rating plate.

Rated voltage, Type of motor, Type of connection, kW rating, frequency, efficiency, power factor, temperature rise of windings in degree centigrade at rated load, and ambient conditions.
Type of bearings, recommended lubricant, lubricating interval & re-lubricating quantity.

8.6.10 Tests

Motor shall be subjected to all the type tests (one from similar rating of each lot) and routine tests as per applicable standard in the presence of the Engineer. Copies of test certificates for all brought out items shall be furnished at the time of inspection for the Employer’s approval. The Contractor shall ensure to use calibrated test equipment / instruments having valid calibration test certificates from standard laboratories traceable to National / International standards.

8.6.11 Low Voltage Motors

Motors shall be suitable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is 85% of the rated motor voltage.

The locked rotor current of the motor shall not exceed 600% of the full load current (subject to tolerance as specified in the applicable standard).

Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation.

Stator leads shall be brought to the terminal box as insulated cable through a suitable barrier and terminated in clamp type terminals.

Motors shall be equipped with smart sensors for condition monitoring, enabling predictive maintenance. Condition monitoring enables the planning of maintenance activities, reducing downtime and supporting longer motor lifetimes. At the same time, the solution generates big data on the status of large

numbers of motors, paving the way for predictive operations and optimized energy consumption.

The sensor monitors signals from the motor, accurately measuring key parameters at regular intervals, and transfers the data, converting it into meaningful information. This information is then sent to the user's smartphone and customer portal via built-in Bluetooth Low Energy technology, which connects to a smartphone or gateway and a secure cloud-based server.

The smart sensor shall measure the following parameters:

i) Overall motor condition
ii) Overall vibration
iii) Bearing condition
iv) Misalignment
v) Skin temperature
vi) Output power, operating hours, number of starts, and speed.

Motors rated 7.5 kW and above shall be provided with space heaters with adequate capacity to maintain motor temperature to prevent moisture condensation on the insulation during idle condition. The space heaters shall be suitable for a 240V single-phase 50 Hz supply. The degree of enclosure protection of motors shall be a minimum of IP 55.

8.6.12 HV Motor (For Process Air Blowers)

Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is 80% of the rated voltage.

(a) Motors shall be capable of satisfactory operation at full load at a supply voltage of
80% of the rated voltage for 5 minutes, commencing from hot condition.

(b) The locked rotor withstand time under hot conditions at 110% rated voltage shall be more than starting time at minimum permissible voltage by at least two seconds or 15% of the accelerating time whichever is greater. The locked rotor current of motors shall not exceed 600% of full load current of motors which is inclusive of 20% tolerance.

(c) Motors when started with the drive imposing its full starting torque under the specified supply voltage variations shall be capable of withstanding at least two successive starts from a cold condition and

one start from a hot condition without injurious heating of windings. The motors shall also be suitable for three equally spaced starts per hour under the above-referred supply conditions.

(d) The three phases shall be segregated by metal barriers within both line and neutral
Terminal box.

(e) The earthling pads shall be of non-corrodible metal, welded/brazed at two locations on opposite sides. The pad size shall be 75 x 65 x 25 mm with two holes drilled at 40mm centers, tapped & provided with suitable bolts and washers for connecting the earthling strip.

(f) At least six resistance type temperature detectors for the stator winding each having D.C. resistance of 100 ohms at 0 degrees Celsius, embedded in the stator winding at locations where highest temperatures may be expected, shall be provided. The material of the RTD's shall be platinum.

(g) At least one vibration detector for the stator winding, embedded in the stator winding at location where vibration may be expected, shall be provided. Compression-type piezoelectric accelerometers, velocity transducers, or proximity transducers should be used in the vibration detection system.

(h) Motors shall have space heaters suitable for 240V single phase 50Hz AC supply. These shall be placed in easily accessible position in the lower part of motor frame. Provision shall be made to measure the bearing temperature by inserting a handheld temperature measuring device.

(i) Motors shall have drain plugs so located that they will drain water, resulting from condensation or other causes from all pockets in the motor casing.

8.6.13 Induction Motor (Submersible Pump & mixer)

Performance and Characteristics

a) The submersible motor shall conform to IS: 9283 and the submersible cable shall conform to IS: 9283. The motors shall be suitable for operating on a 415 V, 50 Hz, 3 Phase, Ac supply. Pump motor shall be of the squirrel cage submersible type, protected to IP 68. Motor for submersible pump shall be capable of startup and operation in the event of a completely flooded wet well. Motor cooling for submersible pump must be achieved

by internal cooling jacket, using the glycol water to cool the motor. This motor shall be capable of starting 10 times per hour. The insulation class of motor winding shall conform to class F/H as specified in the pump or mixer specification. Additionally, the specific requirements mentioned in the following clauses shall also be met. The motor shall be the most energy-efficient type.

b) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:

(i) Variation of supply voltage from rated motor voltage ±10%
(ii) Variation of supply frequency from rated frequency ±5%
(iii) Combined voltage and frequency variation ±10%

The starting current of the motor shall not exceed 300% of the rated full load current for soft starter starting and 600% of the rated full load current for DOL starting, under any circumstances.

Motors shall be suitable for full voltage direct-on-line starting or soft starter starting.

Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is in the range 85% of the rated motor voltage to maximum permissible voltage.

The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerance as per the applicable standard) unless otherwise specified.

Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation. The motor vibrations shall be within the limits specified in applicable standard unless otherwise specified for the driven equipment.

Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standard, IS: 9283.

Motor insulation shall conform to Class F/H as specified in the pump or mixer specification and the maximum temperature rise shall be limited to class B. The

motor windings shall be protected with a waterproof material and shall incorporate a thermal sensor in each phase to safe guard against high winding temperatures. The thermal sensor shall be connected into the control circuit of the starter and signals taken for continuous monitoring of winding temperatures. The motor shall incorporate a cut out device to detect the presence of any liquid in the motor enclosure, in the form of non-resetting moisture switch. The terminal connections for the power and protective circuits shall be housed in a completely sealed and water proof junction box, complete with all external corrosion resistant cable glands. The pump units shall be provided with power and protection circuit cables of sufficient length to reach from the motor junction box to the local isolator located at the panel floor level.

Protection against increase in stator winding temperature bearing temperature, leakage in stator housing and terminal box shall be provided. Minimum three number thermistors are to be provided to sense the stator winding temperature. Sensors are to be provided to detect if the leakage of sewage into the oil housing is above 30 % concentration.

Bimetallic thermal switch to trip the motor against increase in temperature shall be provided.

The power rating of the motor shall be larger of the following:

(i) 115% of the power input to the pump at duty point at a speed corresponding to the frequency of 50 Hz.
(ii) Maximum Power input while operating single pump corresponding to the speed of 50 Hz.

Motor shall be offered for routine and type tests in accordance with IS: 4029 and IS: 325 at the manufacturer’s works.

8.6.14 Submersible Cable

(a) The submersible cable shall conform to IS: 9283. The power cable shall be PVC insulated and PVC sheathed, flexible, 3 core or 4 core flat type with insulated leads. The size of the conductor shall be adequate for continuous use under water and air. The fourth core shall be used for earthing. The motor cable length shall be as per site requirement.

(b) The control cable shall be PVC insulated PVC sheathed, flexible, flat type and shall be adequate for continuous use under water and air. The control cable for stator winding temperature sensor (Thermistors) 3 core x 2.5 sq. mm copper conductor and for bimetallic thermal switch 2 core x 2.5 sq. mm copper conductor shall be provided.

(c) In case a joint is required to be made between the lead cable supplied with the motor and the user's cable connectors, a detailed procedure of cable jointing to make a watertight joint shall be provided by the manufacturer.

(d) The size of the conductor and length of cable should be suitably selected so that the voltage drop at motor terminals does not exceed 3 percent of the rated voltage.

(e) Cable Glands shall generally be of the mechanical double compression hexagon type Earth continuity of brass glands shall confirm to BS: 6121 / EN 50262. This may be achieved by the rigid clamping of the armour within the gland and the intimate contact between the threaded components of the gland and the equipment.

(f) Each gland shall be installed complete with proprietary earth tag providing a ready means of connecting a flexible strand or strip earth bond to the gland at any position around the gland in relation to the associated apparatus. Adequate earth continuity shall be assured between the earth tag, the gland and the armour wires of the cable where applicable.

(g) Each gland shall be installed complete with a proprietary non-ferrous lock-nut to secure the gland body to the equipment where the entry hole is plain, i.e. not tapped.

(h) Earthing

Earthing of the motor shall be done in accordance with the relevant provisions of IS: 3043. For the purpose of earthing these motors, earthing connection may be made to discharge pipe. All the materials and components for the motors shall be suitable for application in respect of corrosion resistance and mechanical performance continuously under water.

8.6.15 Insulation

(a) Any joints in the motor insulation such as at coil connections or between slot and end winding sections, shall have strength equivalent to that of the slot sections of the coil.

(b) The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The tropicalising treatment shall be as per the applicable standard.

(c) The stator winding shall be made from high conductivity annealed copper conductor, PVC insulated winding wires conforming to IS: 8783 for wet type motors. The stator winding shall be of high conductivity annealed copper enameled insulated wires conforming to IS: 4800 (Part-VII) for dry type motors.

8.6.16 Temperature Rise

The temperature-rise test of the motor shall be carried out with the motor coupled to the suitable pump as per relevant standard.

8.6.17 Constructional Features

The motor shall be suitable for continuous use in fully or partially submerged condition. A built-in cooling system must allow the motor to operate continuously at its rated output regardless of whether the electric motor is submerged or not, by providing either external or internal cooling arrangement.

8.6.18 Terminal Box

Terminal box shall be of weather proof construction to eliminate entry of water and dust.The terminals shall be of the stud type with necessary plain washers, spring washers and check nuts. They shall be substantially designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearance.

8.7 Sluice Gate & Weir Gates

8.7.1 **Cast Iron Gate:**

(a) Design Requirements and Construction Features

The construction of sluice gates shall be in accordance with the specification and generally as per IS: 13349. All sluice gates shall be of the rising spindle type.

(b) Frame

The frame shall be of the flange back type and shall be machined on the rear face to bolt directly to the machined face of the wall thimble.

(c) Seating Faces

Seating faces shall be made of full width, solid section; dove-tail strips of stainless steel. They shall be secured firmly by means of counter sunk fixings in finished dove-tail grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in place, free from distortion and loosening during the life of the sluice gates.

(d) Wedging Devices

Sluice gates shall be equipped with adjustable side, top and bottom wedging devices as required providing contact between the slide and frame facing when the gate is in closed position.

(e) Lifting Mechanism

(i) Sluice gate shall be operated through suitable lifting mechanism which shall incorporate suitable gearing if required, to keep the torque requirement within 7 kg. m.

(ii) Lifting mechanism shall incorporate a strong locking device suitable for use with a padlock or padlock and chain.

(iii) Lift mechanism shall be provided with a suitable position indicator to show the position of the gate at all times.

(f) Wall Thimbles

The cross section of the thimble shall have the shape of the letter 'F'.

(g) Lifting Lugs

Lifting lugs shall be provided for all gates.

(h) Flush Bottom Seal

(i) When sluice gates are provided with flush bottom seals, the wedging device and facing along the bottom edge of the slide and frame shall be omitted.

(ii) A solid square cornered, resilient rubber seal shall be provided on the bottom facing of slide. The seal shall be securely fastened to the bottom face of the slide by a retainer bar and corrosion resistant metal fasteners. The top surface of the bottom facing of frame shall be flush with invert of the gate opening. Bottom facing of the slide shall be accurately machined to contact the seal when the slide is closed.

(i) All the sluice gate and weir gate shall be operated by portable type of electric actuators except at the disc filtration unit which shall have permanently fixed electric actuator with modulating type.

(j) Two nos. Portable type Electric actuator shall be provided for opening and closing of sluice gates, so that the closing and operation time shall be maximum of 10 minutes in each Sewage Treatment Plant and in each ISPS campus.

(k) Provision of safety stop nut on spindle to prevent the chances of over-closing of gate, which may otherwise damage either the spindle or the lifting platform.

(l) The material of construction of sluice Gate shall be as follows:

S. No.	Component	Material
(i)	Wall Thimble	Cast Iron: IS 210 Gr. FG 200
(ii)	Frame and Slide	Cast Iron: IS 210 Gr. FG 200
(iii)	Seating faces	Stainless Steel: ASTM Countersunk fixing A276 type 316
(iv)	Wedge	Stainless Steel: ASTM A743 CF8M or SS316
(v)	Stem	Stainless Steel: ASTM extension A276 type 316
(vi)	Stem nut	Stainless Steel: ASTM A743 CF8M
(vii)	Stem Coupling	Stainless Steel: ASTM A276 type 316
(viii)	Fasteners, anchor	Stainless Steel: ASTM bolts and nuts A276 type 316
(ix)	Lifting mechanism, Pedestal gear house	Cast Iron: IS 210 Grade FG 200

S. No.	Component	Material
	cover and stem guide	
(x)	Lift nut	Bronze: ASTM B 148 (CA952, CA954 or CA958)
(xi)	Stop nut	Bronze: ASTM B 148 (CA952, CA954 or CA958)

8.7.3 Mechanically Operated Stoplogs

The construction and general design of Stainless Steel Stoplogs shall be in accordance with the specifications mentioned here under. They shall be so constructed that there is no undue wear or deterioration during its operative life and so designed that the maintenance is kept to a minimum.

The stoplogs shall be capable of performing the isolation duties in waste water treatment plant and pumping stations for those applications where the side water depth is at least 300 mm less than the height of stoplogs.

The stoplogs as well as stoplog frame shall be made of extruded sections and not fabricated so as to keep welding to minimum.

The Stoplogs shall be designed for seating water pressure equal to the height of the top most log.

The Stoplogs shall have an on-seating leakage rate of not more than 1.25 liters / minutes / meter length of sealing perimeter.

The Stoplogs shall be supplied along with all accessories such as Stoplogs, lifting system, storage rack etc. and miscellaneous items like fasteners, gaskets, anchor bolts etc. required to erect and install these items.

Each Stoplog shall be manufactured as detailed hereunder and shall be supplied duly tested as per requirement. The Stoplog assembly shall be supplied as a factory assembled unit and shipped to site as a ready to install unit.

This assembly shall be uncrated at site and installed as complete assembled unit without stripping down into components. This is to ensure that the performance integrity of the stoplogs remains as factory tested and supplied condition, thus minimizing the influence of the installation process to achieve optimum performance at site after installation.

(a) Constructional Features

The constructional features and details of components of the required stoplogs are to be as under:

The stoplogs shall be made of an extruded section of Stainless steel material of grade 316 and having a minimum thickness of 5 mm. The sections used shall have adequate strength to prevent distortion during normal handling, installation and while in service.

The extruded stoplogs section shall be sufficiently rigid to withstand the designated water head. Maximum bending stress shall not exceed 7600 PSI at the maximum operating head.

The extruded stoplog section shall be designed for adequate and prompt drainage while removal.

The stoplogs shall be provided with lifting pins to enable lifting of stoplogs using mechanically operated lifting beam.

The total height of stacked stoplogs shall be approximately 300 mm above the maximum height of water.

The stoplog sectional height shall not be less than 250 mm and not more than 1250 mm so as to ensure that minimum sectional pieces are provided to achieve the required total height.

Stoplogs suitable for lifting manually using lifting rods should not weigh more than 50 kgs. to enable 2 persons to lift them and transfer to storage rack. Stoplogs suitable for lifting using mechanically operated lifting beam, which can engage / disengage automatically with lifting pins provided on logs, shall be so designed that the total lifting load does not exceed 1000 kgs. including the water pressure acting on the stoplogs.

The aluminium stoplogs shall be provided with minimum 120 micron thick coat of suitable epoxy paint to prevent oxidation of aluminium material.

(b) Stop log Frames

The stoplogs frames shall be made of extruded section of Stainless steel material of grade SS 316 and having a minimum thickness of 5 mm. The sections used shall have adequate strength to prevent distortion during normal handling, installation and while in service.

The stoplogs frames shall comprise of bottom invert section and two vertical side guide section for housing the stoplogs. The frames shall be suitable for embedment in two parallel walls on sides and in floor invert at bottom.

The vertical sides of the frame shall extend up to the top of the operating platform to facilitate the removal and insertion of stoplogs. For lengths above 3 meters the vertical side guides can be provided in sectional construction.

(c) Seals

The stoplogs sealing arrangement shall comprise a continuous resilient seal along the bottom and both sides to restrict leakage in accordance with the requirements listed in this specification. The resilient seals shall be of EPDM or Neoprene rubber as per ASTM D2000. The side seals shall be mechanically retained and all the seals shall be easily replaceable. Seals fixed by gluing will not be accepted. The fasteners used shall be of stainless steel material as specified.

(d) Lifting Beam

Lifting beam shall be provided to insert and pull out the stoplogs using an electric hoist arrangement. If the hoisting weight of stoplog is over 50 kgs then suitable provision for handling the stoplogs with the lifting beam should be provided by the contractor. The lifting beam shall be designed to automatically engage with an installed stoplog and lift the same out of frame. The lifting beam also shall have arrangement to disengage the stoplogs by an operator standing on the platform. One lifting beam shall be provided for stoplog having same / equal width in the plant. The lifting beam shall be constructed of Carbon steel material with epoxy painted and shall be designed to lift a load of minimum 1500 kgs.

(e) Storage Rack

A movable storage rack shall be provided to house the stoplogs and lifting beam when they are not in use. The storage rack shall be of stainless steel. The storage rack shall be so designed that the resilient seals of the log shall not remain under compression during storage.

The material of construction for various components shall be as under:

Component	**Material**
Stoplogs & Frame	Stainless steel AISI 316
Resilient Seals	EPDM ASTM D2000
Rubber seal retainer bar	Stainless Steel ASTM A 240 type 316
Assembly bolts, nuts and fastener	Stainless Steel ASTM A 276 type 316

8.7.4 Weir Gates

The downward opening weir gates shall be manufactured from Cast Iron and shall be Flange back type suitable for wall mounting and manufactured in line with provisions of AWWA C-560 / IS 13349 with improvements as desired and specified hereunder for weir application.

The weir gates shall be capable of performing continuous weir duty in plant and shall be so constructed that there is no undue wear or deterioration during its operative life and so designed that the maintenance is kept to a minimum.

The weir gates shall be designed for water tightness at any level of opening for off-seating pressure equal to depth of shutter. The weir gates shall have off-seating leakage rate of not more than that permitted under AWWA-C560 / IS 13349.

All the weir gates shall be shop tested to verify the leakage performance at operating head, torque tested at operating head to verify the suitability of actuating mechanism and PMI tested to verify the correctness of the material used. This testing will be done in presence of client / client representative or approved third party inspection agency.

The weir gates shall be rising spindle type and the operation shall be by means of Manual / Electric operating mechanism.

The weir gate shall be supplied along with all accessories such as gates assembly, gasket between wall and gate assembly, studs and nuts for mounting on wall, stem connecting block, spindle, spindle couplings, spindle guides, pedestal, operating mechanism as required, gate opening indicating arrangement and required anchor bolts and fasteners for stem guides and pedestal.

The main gate assembly comprising of frame, guides and shutter will be supplied as a factory assembled unit and shipped to site as a ready to install unit on the wall. This gate assembly will be uncrated at the site and installed as a complete assembled unit without stripping down into components. This is to ensure that the performance integrity of the weir gates remains as factory-tested and supplied, thus minimizing the influence of the installation process on achieving optimum performance at the site.

(a) Constructional Details :

The weir gates shall be manufactured generally as per provision of AWWA C-560 / IS-13349 with suitable changes for weir application. The constructional features and details of components of the required gates shall be as under:

(b) Gate Frame

The gate frame will be made from cast iron and shall be sufficiently rigid to withstand the designated water head. The gate frame shall be flange back type to suit the designed head and site condition. Back flange of the gate aperture frame to be precisely machined flat and drilled to engage with the face wall. A rubber gasket will be provided between the wall and the gate for ease in future dismounting of the gate for repairs / replacement and seal any leakage between the flange of frame and the wall. The gate frame of these sluice gates shall either be self-contained type or non-self-contained type depending upon site requirement. In case of non-self-contained gates the frames shall be without yoke at their top. In case of self-contained gates the frames shall have extension guides of requisite length and shall be provided with a yoke at their top. The length of guides shall be sufficient to engage at least half the overall vertical height of door when the gate is fully lowered to open and shall be in accordance with the relevant provisions of AWWA C-560 / IS-13349.

(c) Gate Slide / Shutter/ Door

The gate slide / shutter will be made from cast iron and shall be sufficiently ribbed to withstand the designated water head. The gate slide / shutter will be provided with integral pocket to house the thrust nut used to connect the stem with the slide.

(d) Seating/Sealing Faces:

Seating face shall be of Stainless steel. The seating / sealing faces on door shall be secured in place using taper screws which cannot be mechanically removed after fitting on facings. The taper screws adopted for facings shall be of same material as that of the seat facings.

To enable continuous sealing at any level of opening of the downward opening weir gate so as to achieve precise level control, the full face of the shutter will be fitted with specified seating / sealing faces and the sealing faces on shutter will always be in full face contact with corresponding metal / resilient sealing arrangement mounted on frame perimeter.

The mating seating/sealing faces on the gate frame and door shall be precisely finished for proper contact. They should be so finished that the clearance or gap, if any, between the mating sealing faces does not exceed 0.1mm at any level of weir gate opening.

(e) Manual Gate Operating Headstock/Lift Mechanism

The operating headstocks shall be designed in such a manner as to permit the gate operation by a single Person under the specified maximum operating head with an effort of less than 18 Kgs. on the crank /hand wheel.

The headstock may be ungeared or geared type and the geared headstock may be either of single speed or of double speed, as might be necessary to make it convenient for one person to open or close the gate as fast as practicable. Two speed headstocks shall be supplied with gates requiring higher hoisting capacities. In this type of headstock the low speed is meant for crack opening the gate when the effort required to open the gate is maximum and the high speed is meant for further faster opening after the gate is crack opened.

Geared headstock shall be supplied with easily removable crank handle or hand wheel with a radius not exceeding 375 mm.

All the gears of geared headstock shall be kept completely encased in cast iron housing to protect them from damage, dirt, dust, water etc. and other atmospheric effects and thus ensure their smooth operation. Grease Nipples shall be provided for lubricating with grease.

Headstock meant for mounting on operating platform shall be supplied with a pedestal/floor stand to provide a convenient operating height of approximately 900 mm. The pedestal of the headstock shall be provided with a covered window opening to enable cleaning and greasing of stem threads.

(f) Lifting Spindle/Stem

The sluice gates shall be supplied with Rising type lifting spindles/stems. The stem shall be provided with acme / square threading, length of threaded portion being about 400 mm more than the height of waterway opening. This much extra length is required to allow for a minor variation of approximately 100mm on either side of the specified height of operating platform. Provision of safety stop nut on spindle to prevent the chances of over-closing of gate, which may otherwise damage either the spindle or the lifting platform.

The design of stem will be done as per the provision in AWWA C-560 / IS-13349.

(g) Stem Block/ Thrust Nut

The rising type stem shall be connected to the door through a stem block/thrust nut housed in a ribbed pocket cast integral with the door. The bottom end of stem

shall thread into the stem block and is locked in place by a set screw to prevent the stem from unscrewing. The Stem block shall be cast bronze or Gunmetal.

(h) Safety Stop Nut

The stem shall be provided with a safety stop nut to prevent the chances of over-opening of gate, which could result in the spindle unscrewing from the operating nut and falling of the shutter. The stop nut shall be furnished with a set screw for setting it in a fixed position after the gate is installed. Upon installation the safety stop nut should be set in such a way that its bottom remains about 1 to 2 mm away from the top of headstock, in gate open position. In case of stainless steel stem, the stop nut shall also be of stainless steel material of the same grade.

An adjustable stopper arrangement will be provided on the frame and this stopper will engage with corresponding arrangement on shutter so as to prevent over closure of the shutter.

(i) Stem Coupling

For ease in transportation and handling, the maximum length of a piece stem shall be limited to 5 meters. Where the stem is required to be furnished in more than one piece, threaded stem couplings shall be furnished to interconnect different sections of the stem. The couplings shall have provision for pinning after inserting into the threaded end of the stem. In case of a stainless steel stem, the couplings shall also be of the same grade of stainless steel.

(j) Stem Guide Bracket

Longer stems shall be provided with sufficient number of stem guides to prevent buckling of stem. The stem guide bracket to be provided shall be Adjustable Centre Type - wherein a separate stem guide is bolted on to the wall bracket. The stem guide shall be adjustable in the slots on wall bracket in a direction perpendicular to the face of wall. Wall bracket should also offers minor adjustment in the direction parallel to the wall. The stem guides shall have machine bored split journals to facilitate erection. The journal shall be lined with brass/gunmetal bush.

(k) Pipe Hood For Stem

A Pipe hood shall be provided on the top of headstock in case of rising spindle/stem gates to cover the spindle threads for protection against damage, dirt, dust, water etc. It shall be made of transparent fracture resistant polycarbonate material. The pipe hood shall have vent holes to prevent condensation.

(l) Gate Opening Indicating arrangement

Gate opening indicating arrangement shall be provided to indicate the position of the shutter. This shall comprise of scale mounted on the pipe hood and an indicator nut mounted on the rising spindle to show the extent of the opening and closing. The minimum scale graduation shall be 25 mm.

MATERIAL OF CONSTRUCTION:

The material of construction for various components shall be as under:

Component	**Material**
Gate frame, Shutter	Cast Iron to IS:210 Gr FG 200
Headstock, Stem Guides, Stem Guide Bracket	Cast Iron to IS:210 Gr FG 200
Seating faces,	Stainless Steel ASTM A 240 type 316
Rubber Seals	EPDM Rubber to ASTM D 2000
Rubber seal retainer bar	Stainless Steel ASTM A 240 type 316
Assembly bolts, nuts and fasteners	Stainless Steel ASTM A 276 type 316
Stem & Coupling	Stainless Steel ASTM A 276 type 316
Yoke	Steel Epoxy painted
Stop Nut, Thrust nut and Lift nut	Gunmetal / Phosphor Bronze

8.8 Trash Rack and Solid Grabbing Unit

8.8.1 Scope of Supply

The scope of supply shall include Trash rack system with all accessories and appurtenances, including, but not limited to:

- Removable J-type Trash racks (MOC:SS 316) which are installed by lowering the same inside guide channels or grooves provided in the trash rack channel so that the trash racks may be readily removed by lifting them through guides.

- Lifting Arrangement by one number electric hoist shall be provided for each manually raked screen and the same shall be permanently attached to screen.

- Rakes for manual cleaning after bringing them on cleaning area.

- Solid Grabbing Unit shall be provided for lifting large volume of solids from the Coarse Screen channel of TSPS/ISPS.

- Electric Hoist and Solid Grabbing unit shall be accommodated adjacently with the I girder arrangement.

8.8.2 General

One trash rack will be installed before the mechanically operated screen, with one working. The structural arrangement of racks generally consists of equally spaced trash rack vertical bars supported on horizontal members connected to end vertical members, which sit in the grooves of guide rail. The trash rack will have J-type structure at the lower end for support and for collection of screened material which will extend for minimum 600 mm from vertical bars. Hook will be provided at the upper end for lifting of the Trash Rack by Hoist. The minimum thickness of the bars will be 10 mm, width 50 mm it should preferably be fabricated from flats with rounded edges. A platform at suitable/finished ground level shall be provided to manually clean the trash rack by raking and by water jetting arrangements for the collection of screenings in a portable screening container.

All the screens shall be provided with 2 sets of SS 304 cleaning rakes with appropriate grip handle.

8.8.3 Aperture Size

The screen apertures shall be sized to capture particles of 60 mm and above in size. The clear spacing between the bars will be 60 mm.

8.8.4 Inclination of Trash Racks

Racks will be installed on guide rails, which will be kept in a vertical position at 90 degrees.

8.8.5 Velocity through racks

Velocity up to 1.2 m/s at peak flow and 0.6 m/s at average flow on the gross area of racks may be permitted.

8.8.6 Required Downstream Water Level

Contractors should state the maximum and/or minimum allowable water levels downstream of the screen in order to pass the required flow.

8.8.7 The Material of Construction

The material of construction of the trash rack equipment shall be in grade 316L stainless steel.

8.8.8 Manual Raking and Screenings Removal

Suitable arrangement should be made for cleaning the racks manually at regular intervals after removing the trash rack installed in channel through guide rail.

The frequency of cleaning of the racks would depend upon the rate of accumulation of trash. Not more than 33 percent of the trash rack area should be allowed to clog the racks at any time. The raked screenings will be collected in portable screenings container.

8.8.9 Structural Requirements

Structural connections in the trash rack should be designed and provided for the failure load of the structural members. All flats should be welded to the intermediate horizontal members and the top and bottom horizontal members for better resistance to vibrations and to avoid stress concentration at the external edge of the groove. The vertical member of the trash rack should be so arranged as to apply the load near the inner part of the rack guide. The guides of the trash racks should be so proportioned that the side members get lateral support from guides after deflection to take up the clearance in the slots.

8.8.10 Access

Safe access shall be provided to all trash racks when hoisted to allow for cleaning, inspection and maintenance activities.

8.8.11 Corrosion Resistance

All metal parts of the screen equipment that are in contact with the sewage shall be constructed of a suitable grade of corrosion resistant stainless steel 316.

8.8.12 Working Stress and Design

The design of all parts shall ensure that under the most onerous of conditions they will not be damaged or corroded.

Any joint that will need to be dismantled during maintenance shall be made by anti-corrosion type fasteners.

All spare parts shall be fully interchangeable with the original part. If the spare part is unavailable due to cease of production, the Contractor shall give notice to the Employer in writing, detailing the options available to the Contractor.

All parts shall be designed to minimize the risk of fire and consequential damage. All parts shall be designed to prevent the ingress of vermin, dust and dirt. All electrically live or moving parts shall be adequately guarded to prevent accidental contact.

8.8.13 Screen solid Grabber Mechanism:

General:

The Grabber Mechanism consists of an overhead monorail system, a travelling trolley, and a grab unit.

The overhead monorail will be formed from minimum 12 mm thick single plate to the required section. This provides a track for the drive and support wheels fitted to the top of the travelling trolley.

The single overhead track will be supported on hollow steel columns and will extend over the width of the bar screen and dump areas.

The trolley unit contains the hoisting unit for the grab and the hydraulic power pack for the operation of the hydraulic cylinder on the grab itself. It is traversed by a geared motor unit mounted on top of the trolley at one end. Polyurethane coated wheels fitted directly to the gearbox output shaft, run on the inside of the monorail sections. A second pair of free running support wheels keeps the trolley parallel with the track.

Power to the trolley will be supplied by a trailing cable which contains both power and control leads and is supported on cable carriages also running in the monorail sections.

The grab unit consists of a series of fingers which are opened or closed by a hydraulic ram. The hydraulic hoses, carrying power to the ram from the power pack in the trolley, are wound on one spring tensioned drum which operate in sequence with the hoisting drums for the grab support ropes. The grab is laterally held in the upper position by spring loaded swing restrictor plates.

The trolley movement and hoisting speed shall be

Hoist Speed:	10 m/min (Minimum)
Traversing Speed:	20 m/min (Minimum)
Grab Opening Closing:	Based on Vendor recommendations
Maximum Solid Load:	1000 Kg S.W.L
Grab Opening/closing time:	Based on Hydraulic power pack movement and actuation.

In operation, the trolley and grab with the fingers open, moves out along the monorail until it is in the first raking position. Here a proximity switch on the trolley senses a position plate on the monorail, the trolley stops and the grab is lowered.

As the grab descends, the downstream fingers engage with the screen bars and top bars on the grab push any accumulated debris to the screen invert. At the invert, the grab stops and the fingers are closed by the hydraulic ram. The grab is then raised, together with any collected debris.

When the grab reaches its top position, the trolley is traversed back to the selected dump position where the fingers are opened, and the debris is deposited. The trolley and grab then return to the next raking position. The number of raking positions is dependent on the overall width and design of the screen. Each raking position is controlled by a proximity plate on the monorail and the position selected is determined, in automatic mode, by a Programme Logic Controller (PLC). When all positions have been raked, the trolley returns and stops at a pre-determined park position.

If a large amount of debris, or other obstruction prevents the grab reaching the screen invert, slack rope devices on the trolley stop the lowering motion, the fingers are closed, and the grab lifted. The collected load is taken to the dump area and deposited. The trolley then travels to the next raking position and continues its cycle.

The top and bottom hoist limits are determined by a rotating arm limit switch unit driven from the main hoist shaft. In addition to the switches for determining the raking and dump positions, limit switches are fitted to each end of the trolley to prevent it contacting the end of the monorail.

The hoist and slack rope proximity switches are backed up by direct contact mechanical limit switches, as a safety precaution.

The hydraulic power to the grab is supplied by an electrically driven pump directly mounted on a tank in the travelling trolley.

When the grab reaches the screen invert, the downward travel is stopped by the preset limit switch, the hydraulic pump motor starts, and a spool valve directs the oil to close the hydraulic ram.

The electrical controls then continue the sequence until the trolley is in the dump position where the spool valve moves to the open position and the hydraulic pump motor is again started.

As soon as the ram is fully open, the hydraulic pump motor is stopped and the electrical sequence controls are re-activated.

In addition to the pressure and spool valves mentioned above, controlled return flow valves are fitted in the lines to the hydraulic ram and a pressure safety valve, set at 120 bar is fitted to the pump discharge.

A return filter with a renewable element is fitted on the tank cover. The filter element is spring loaded to provide bypass if the element becomes blocked.

A low oil level switch is fitted in the hydraulic oil tank (and also a timer is included in the PLC circuit) to prevent loss of oil in the event of a pipe fracture. A pressure gauge and oil level sight glass are also fitted.

MATERIALS OF CONSTRUCTION

Monorail Track:	Hot Dipped Galvanised Mild Steel/Carbon Steel
Structural Columns:	Hot Dipped Galvanised Mild Steel/Carbon Steel
Maintenance Platform:	Hot Dipped Galvanised Mild Steel/Carbon Steel
Trolley Enclosure:	Stainless Steel Gr.304
Trolley Frame:	Hot Dipped Galvanised Mild Steel/Carbon Steel
Grab:	Hot Dipped Galvanised Mild Steel/Carbon Steel
Hydraulic hose drum:	Hot Dipped Galvanised Mild Steel/Carbon Steel
Stainless Steel Gr.304	
Cable Drums:	Hot Dipped Galvanised Mild Steel/Carbon Steel
Fixings & Fastenings:	Hot Dipped Galvanised Mild Steel/Carbon Steel & Stainless Steel 304
Hydraulic Tank:	Mild Steel/Carbon Steel epoxy coated
Hydraulic Oil:	As per vendor recommendations
Hoist Cable:	Stainless Steel Gr. 316
Cable Trolley:	Stainless Steel Gr. 304
Sprockets (If applicable)	Carbon Steel epoxy coated
Chains (If applicable)	Stainless steel Gr. 316

Other fixings such as the structural fixing bolts for the gantry and foundation fixings will be galvanised carbon steel.

Motor and control Operation.

Motors shall be squirrel cage type conforming to IS 12615, IS/IEC 60034, IS 15999. The Drive Motor shall be controlled by a Full Voltage Reversing Motor Contactor mounted on a Back Panel to be mounted in an Enclosure or MCC (Motor Control Center) in the main Panel. Motor shall be used for Hoisting, Traversing and Hydraulic power pack units. The power rating of motor shall be at least 125% of maximum power requirement. The other features of motors shall be as follows:

(i) Type of duty : Intermittent (S4)/ Continuous (S1) based on manufacturer's design

(ii) Method of Starting : DOL (VFD if motor rating is above 10 HP and application required frequent starting)

(iii) Voltage : 3 Phase, 415V AC

(iii) Class of insulation : F (Temperature rise limited to class B)

(iv) Type of enclosure : TEFC

(v) Degree of protection: IP 55

(vi) Motor Speed: 1500 rpm

The Control panel shall have IP 55 protection, painted with epoxy paint and it shall be Rust proof and shall be comprising of

- Mushroom head emergency stop.
- Overload relays for motor protection.
- Indicating lamps for the functions.
- MCB/MCCB protection
- Control Transformer
- Earthing terminals
- Provision for suitable PLC circuitry shall be provided in case of connectivity and remote monitoring for the plant SCADA system.

8.9 Mechanical Coarse Bar Screen-TSPS & ISPS

8.9.1 General

(a) The screen shall be installed in raw sewage inlet channel, and the screen shall be of the front raking type. Inclined Bar screen at 75 degree and the minimum bar thickness shall be 16 mm x 20 mm with 50 mm width of the bar.

(b) The screen shall be capable of performing the duties set out in this Specification. All the materials and sub-assemblies used shall be suitable for outdoor application. They shall be constructed to minimize maintenance requirements.

(c) Ideally, any moving parts such as sprocket, bearings, etc. should not be in immersed in sewage. In case immersed, the parts shall be of such materials that require little or no maintenance. All lubricating points shall be conveniently accessible from the deck level.

(d) The screen shall be suitable for discharging 75% of the screened material lifted from the screen into the chute.

(e) The screen shall be designed such that in case of heavy accumulation of solids, the same is to be removed gradually without overloading or damaging the screen bars or mechanism.

8.9.2 Frame work

The framework of the screen shall be of robust construction with intermediate cross-bracing. The lower ends and sides of the frame shall be grouted in concrete. Each screen shall have an independent canopy at the top for weather protection. Framework of screen shall be constructed of Grade 316 stainless steel and cross section with a minimum thickness 6 mm. Various parts fastened by welding or bolting shall be braced as necessary to ensure a rigid structure. The side frames shall be minimum 6 mm formed to a channel profile. The bottom thickness shall be minimum 6 mm. The frame shall have support beams with U or C-profile minimum thickness of 6 mm on the front above the maximum water line. The Screen Frame shall be supplied in one piece, requiring no field assembly. Bars shall be supported from framework.

8.9.3 Screen bar assembly

Screen bar assembly shall be fitted across the screen chamber. Screen shall have a series of vertically oriented bars spanning the inlet channel and spaced as specified. Bars shall be sufficiently rigid to prevent vibrations in stream-wise and lateral modes and to withstand the maximum differential head that will occur with the screen totally blinded. Bars shall have tapered cross section to prevent jamming of screenings between bars. Bars shall have supports only at both ends.

8.9.4 Rake carriage

The design shall be multi rake and the rake carriages shall comprise a stiffened frame work to which is attached replaceable rake tines. Rake carriage shall incorporate suitable devices to enable the rake to ride over any small obstacles wedged in the screen and automatically stop the drive motor in the event of the rake jamming against a large obstruction. There shall be no mechanical damage resulting from obstructions wedged in the screen bars. The rake carriage shall always come to rest in a parked position with the rake above the sewage level.

The raking tines shall have the tooth profile precision cut from a single continuous bar of enough thickness and depth to ensure adequate stiffness and strength to cope with the specified duty cycle. The rakes shall run in guides on both sides to ensure engagement and clean the bars from the upstream side of the screen. The rakes shall be fabricated from stainless steel Grade 316L. The rake material, thickness of material, and capacity of the rake are similar to the entire construction. The rake tines shall be suitable to accommodate bulky screenings.

Thickness of rake blade 10mm
Reinforcement profile 6 mm
Rake Side Plates 6mm

The screen shall be cleaned automatically through an adjustable timer. The rake lowered will clear screen bars at the beginning of a cycle and accurately engage with the screen bars at the bottom of the channel. The tine profile and rake motion shall be designed to elevate screenings to the discharge chute at deck level, ensuring they do not wrap around the tines or the stationary bars, and also prevent them from falling back into the sewage flow during the cleaning cycle. The rake shall be suitable for elevating debris encountered at any level. Rake tines shall be replaceable.

Screenings transported to the top of the screen shall be discharged positively by means of a scraper mechanism to the discharge chute leading to a screw conveyor system. A scraper blade made of a combination of synthetic and other material shall be provided on the scraper. The rake tines shall then be retracted, and the unit shall be ready for the next cycle. Drive chains, chain guides, chain sprockets, bearings, and axles shall be fully replaceable without having to remove the screen from the channel.

8.9.5 Rake Lifting Mechanism

Lifting Mechanism Chains shall be roller type chains and made of SS 316L and SS 316 sprocket of high tensile strength and resistance to corrosion. The maximum each chain take-up is 112,000 Newton. Chain Pins shall be a Stainless Steel and hardened.

Chain guide shall be securely fixed to the Screen frame for the full height of travel and shall not protrude into the flow. The type of chain guide, thickness of material and size is an L-Profile, Material Grade 316 Stainless Steel. Upper Bearings shall be of UCF Type or equal; housed bearings are grease-lubricated, mounted the Take-Up Frame assembly. No Bearings shall be submerged in the waste stream.

8.9.6 Inspection Platforms

An inspection platform shall be provided for periodic checking and maintenance of the drive and other critical parts. A ladder with handrails for access to this platform shall be fixed. Suitable hand rails shall be provided for safety on the inspection platform and also at deck level. The platform shall have holes to prevent rain water accumulation.

8.9.7 Dead plate

A SS316L dead plate extending from the top of the bars to the deck level shall be provided to ensure that screenings do not fall back. Dead plate shall be made of minimum 6 mm thick plate. The clearance between the tines and the dead plate shall not exceed 6 mm.

8.9.8 Discharge Chute

A discharge chute shall be of minimum 3mm thick provided for each screen to divert screenings discharged from the screen to a conveyor mechanism. The discharge chute shall be made of SS 316. The discharge chute shall be mounted at an angle of minimum 30 degrees. Panels are positioned on both sides to protect from splashing.

8.9.9 Covers

Covers which are easily removable shall be provided for easy maintenance. Covers shall be constructed of clear impact-resistant Polycarbonate material thickness 6 mm and SS 316 thickness is 2 mm to allow for visual observation during screen operation.

8.9.10 Driving Mechanism

The driving mechanism shall consist of a sturdy reduction gear unit driven through multiple 'V' belts or directly by an electric motor. Motor shall be mounted in such a way that the tension of the 'V' belts can be adjusted. A manually reset torque limiter shall be provided between the motor and gear unit, incorporating a limit switch to cut off the supply to motors in the event of an overload. The drive mechanism for the rakes shall incorporate a solid shaft constructed of SS 316.

8.9.11 Installation

The screen shall be designed for installing to (a) pivot out of the channel, (b) be pulled out of the channel. Non-metallic side flaps seal the screen to the channel walls, or (c) The Screen shall be grouted in a wall recess and/or floor recess.

8.9.12 Gear Reducer

(a) The reducer shall be sized and selected with a minimum service factor of 2.0 times the motor horsepower rating in accordance with applicable American Gear Manufacturer's Association Standards. The reducer shall have a life of 40,000 hours based on the motor horse-power. The reducer shall have an efficiency of not less than 90% based on reducer input.

(b) All gear meshes shall be oil lubricated. All gears shall be provided with an oil reservoir for instant lubrication on starting. The gear reducer housing shall be provided with an oil level indicator and an oil drain with necessary fittings.

(c) The gear reducer shall be of cast iron construction. The reducer housing shall also include suitable lifting lugs and external gear train inspection covers for each gear train. The gears shall be matched for maximum tolerance variation. The gear reducer shall be suitable to reduce the motor asynchronous speed to achieve the required speed of raking.

8.9.13 Control System

(a) The screening operation shall be carried out through adjustable timers which are adjustable at site for 0-60 minutes interval between two operations.

(b) Control system for the conveyor shall be designed to achieve the following:

(i) Conveyor shall be started when any of the rakes starts its upwards travel.

(ii) Conveyor shall be stopped with a time delay (by adjustable timer) after rake is stopped.

(c) Weatherproof, lockable, emergency mushroom headed stop push buttons shall be provided near each motor for screen and screw conveyor, operation of stop push button, and overload prevention for screen and screw conveyor shall be included in the control scheme.

8.9.14 Screw Conveyor with compactor

Technical specifications of Screening Conveyor

The Screening Conveyor shall be Shaft Screw Conveyor and applied for conveying the floating debris to the next facilities. The screening system shall be supplied with a shaft screw conveyor that will be used to convey the screenings to the automatic screenings press and discharge system that compacts, dewaters and discharges the screenings through a chute to the screenings storage system.

Dumping of the screenings to the duty/standby conveyor opening shall be with the automatic deflection plate, which shall be positioned towards the conveyor that is selected from the LCP/SCADA for the duty and automatically towards the standby if the duty conveyor trips. Position of this deflection plate shall be interfaced with PLC.

Screening wash compactor shall be suitable for washing and compacting the floating waste coming out of the duty and standby shaft screw conveyor in case of multiple screens, or directly from the screen in case of single screen installed in municipal waste water pumping station or treatment plant.

Shaft screw conveyor shall be made of stainless steel of grade SS 316 and shall incorporate shaft spirals. Cover plates for shaft screw conveyors shall be provided along the entire conveyor length to contain splatter. Conveyor trough covers shall be made from 5 mm of specified grade of stainless steel single piece formed sheet metal, not greater than 1000 mm in length, attached to the screw conveyor trough using toggle clamps. The cover shall also be of sufficiently tight fit to prevent the conveyed media from leaking out of the conveyors. A minimum 2.5 mm neoprene gasket of 50 durometer shall be applied with an appropriate adhesive to the mating surfaces of the trough covers.

Its structure shall have excellent durability for continuous operation over a long time. It shall be abrasion, corrosion and vibration resistance. It should have a structure that is free from debris material clogging.

The spiral flighting for the shaft screw conveyors shall be designed to convey material without a center shaft. The spiral flights shall be designed to ensure stability, preventing distortion and jumping in the trough while operating at the design speed and capacity. The spiral flighting shall be Stainless steel of grade SS 316.

The shaft conveyor trough liner material shall be an ultra-high molecular weight (UHMW) polyethylene with a minimum thickness of 12 mm. There shall be two colored layers in the liner material to indicate wear. The liner shall extend the full length of the trough, covering the entire semicircular bottom portion of the trough. The liner shall be secured at intervals not to exceed 1000 mm, using specified stainless steel retaining clips of an approved design.

Screening wash compactor shall be made of stainless steel of grade SS 316. The wash compactor will receive the waste through the inlet hopper, and the waste shall be dropped into the conveying zone of the compactor's main body.

Screw and liner shall have rigid thickness for resisting corrosion and abrasion caused during carrying of debris. Its structure shall be designed not to invite biting and clogging. Casing shall be equipped with an inspection port for cleaning convenience. The driving device shall have an overload limiting switch to avoid a broken situation caused by overloading.

The conveying zone shall have perforations at the bottom so that the water coming along with the wet screening is dropped in to the dewatering trough. The dewatering trough will have a set of nozzles positioned upwards so that the screening particles clogging the perforations will be removed by the force of spray water. The construction of the dewatering trough shall be inclined towards the drive end so as to enable the flow of water to the drain hole provided with an elbow connection. The compactor main body shall also have a drain hole with an elbow connection.

In the conveying zone there shall not be any impeller wheel or any other mechanical breaking device. The breaking up of organic matter shall be done solely by water through an assembly of nozzles connected with solenoid valves in a special washing zone between the conveying and the compaction zone. The screening shall move towards the compaction zone by a shafted screw of a constant pitch connected to a drive shaft. This drive shaft shall be connected to the drive unit through axial and radial bearings.

An elephant trunk shape outlet tube shall be connected to the compactor body with a flanged connection. An elbow shall be provided at the flanged connection to carry the washed screening in the reduction tube. The reduction tube shall be divergent to ease the push of the washed screening upward in to the outlet tube. The end of the reduction tube shall have an elbow with a discharge plate/chute to enable the collection of the screenings in bagging units or a container.

The Screening wash compactor shall remove the organic material by washing and compaction thus reducing the volume and weight by 50%.

The main body of Screening wash compactor shall have a material thickness of minimum 3 mm and the bottom of the compactor main body shall be perforated with 5 mm holes.

The screw flights of wash compactor shall have a minimum thickness of 12 mm and at the end of compaction zone, there shall be wear bars of 10 mm thickness bolted to the wash press main body/tube for easy replacement.

The elephant trunk shaped outlet tube shall be diverging to prevent the waste getting clogged. The connection of the outlet tube to the main body shall be flanged type. All the bend fittings (elbows) in the outlet tube shall be long radius design.

Frequency Inverter shall be provided for Forward-reverse-forward motion of the screw and as overload protection device.

The gearbox of screw conveyor and wash compactor shall be hollow shaft, parallel helical gear unit have a minimum service factor of 1.2, oil bath lubricated with oil sealing. The motor shall be of TEFC type with minimum IP 55 protection & Class F insulation and be suitable for operation on 3 phase, 415V and

frequency of 50 Hz. The drive shaft must be precisely machined and shall have radial and axial bearings.

The common control panel shall have IP 55 protection, painted with epoxy paint and shall comprise of:

- Mushroom head emergency stop.
- Overload relays for motor protection.
- Circuitry to operate the Screening conveyor and wash compactor with a signal for start command from the screen motor start and a delay-timer-based stop command after the screen motor stops.
- Selector switch to operate the Screening conveyor and wash compactor in Auto, manual and remote mode.
- Provision for suitable PLC circuitry shall be provided in case requirement of connectivity with SCADA system.

The Screw conveyor and wash compactor shall be supplied factory assembled and duly tested at manufacturer's works before dispatch. Upon receipt at site these shall be installed resting on the channel floor and mechanically or chemically anchored on to the platform in a way that there are minimum chances of misalignment.

Material of Construction

Screw	SS 316
Screw trough	SS 316
Screw cover	SS 316
Liner	Ultra-High Molecular Polyethylene (UHMPE)

Accessories

Anchor bolts and nuts	1 set
Special tools	1 set
Flexible joint for inlet and outlet	1 set
Liner (for spare)	1 set

8.9.15 Portable Screenings Container

Portable screenings containers made of galvanized steel shall be provided to store the screenings until time of pick up. Minimum two Screenings Containers shall be provided at the screening chamber. The container shall have capacity of approximate 2.0 cum and shall be of a convenient height to permit the discharge of screenings directly into the container without having to transfer the screenings manually. The containers shall have hinged covers and their design shall permit their being lifted by an overhead hoist or packer truck. The container will have four wheels each of minimum 40 cm diameter, Tyre type. The maximum height of container including wheels shall be 66 cms. The sides shall be constructed of 12-

gauge steel. The bottom of the container shall be made of 5 mm plate steel. The containers shall be reinforced with 50 mm x 50 mm x 5 mm angle.

8.9.16 Automatic Jam removal system

The screen shall have automatic electronically controlled Jam removal facility to ensure smooth operation without damaging the main equipment.

8.9.17 Motors

Motors shall be squirrel cage type conforming to IS 325. The Drive Motor shall be controlled by a Full Voltage Reversing Motor Contactor mounted on a Back Panel to be mounted in an Enclosure or MCC (Motor Control Center) in the main Panel. The power rating of motor shall be at least 125% of maximum power requirement. The other features of motors shall be as follows:

(i) Type of duty : Intermittent (S4)/ Continuous (S1) based on manufacturer's design
(ii) Method of Starting : DOL
(iii) Class of insulation : F (Temperature rise limited to class B)
(iii) Type of enclosure : TEFC
(iv) Degree of protection : IP 55

(a) The material of construction of Mechanical Raked Screen shall be as follows :

S. No.	Component	Material
(i)	Screen	Stainless steel SS316L
(ii)	Frame (Side and Bottom Portion)	Stainless steel SS316
(iii)	Raked tines	Stainless steel SS316L
(iv)	Fasteners including Anchor bolts	Stainless Steel : 316
(v)	Screen canopy	Stainless Steel: SS316L
(vi)	Chutes	SS316

8.10Mechanical Fine Screen-WWTP Inlet

General

The mechanically operated self-cleaning fine screening equipment used to collect the fine sized floating solid from travelling in the screen channels before entering to Grit chamber.

Working Principle

The Raw sewage entering the fine screen channel which contains the solids flowing with the sewage while gets retained on the face of the perforated panels of screen, the water passes through. The Screens comprise of screen frame of rugged construction, Screen elements, discharge chute, set of high-pressure nozzles, a pair of chain and sprockets and high efficiency drive unit. As the endless perforated band of screen elements escalates upward, they carry the deposited waste along with it till the waste reaches to the top of screen. At the turning point where the screen element is about to start its downward journey, solid are dislodged from the filer elements by a series of high-pressure water jets nozzles. The solid will fall on to the in-built chute. From the chute the waste can either be collected into a Screw conveyor for separation of waste and wash water and for further disposal. Screen shall be adopted with cleaning mechanism either brushes with motor drive or water spray bar mechanism.

These fine Screen operates by means of level and clogged condition as detected by a level sensor indication in the screen channel,

(i)The screen shall start when raw sewage level reaches maximum water level, screen will operate till water level achieves minimum water level.

(ii) The screen will operate once clogging indication is detected by level sensor through by means of PLC unit of the screens.

8.10.1 Construction features:

A. Frame work

The framework of the screen shall be of robust construction with intermediate cross bracing. The lower ends and sides of the frame shall be grouted or anchored in channel. Each screen shall have an independent canopy at the top for weather protection. Framework of screen shall be constructed of Grade 316 stainless steel and cross section with a minimum thickness 5 mm. Various parts fastened by welding or bolting shall be braced as necessary to insure a rigid structure. The side frames shall be minimum 5 mm formed to a channel profile. The bottom thickness shall be minimum 5 mm. The frame shall have support beams with U or C-profile minimum thickness of 5 mm on the front above the maximum water line. The Screen Frame shall be supplied in one piece, requiring no field assembly. Mesh / Perforated punched plate hole shall be supported from framework.

B. Screen Assembly

The screen shall be provided with a spray nozzles bar or rotating brush (as per design). The screen panels are made of step-type perforated plates covering the entire width of the screen field and are linked to a continuous chain and sprockets forming an endless band.

Step type perforated plate profile can carry large sized solids and avoids formation of clogging. Use of high-pressure nozzle spray system. Primary system above discharge level ejecting entrapped screenings and secondary wash system bringing any remaining residue through drainpipe back in to upstream of the channel. Heavy duty sprockets and chains made of stainless steel and chain pin made of hardened stainless-steel material of special grade. Special grade ceramic bushes with self-lubricating type shall be provided in lower sprockets to ensure very long operative life. Self carrying design its own weight is sufficient to keep the screen securely in position.

The mesh/Perforated punched plate is a combination of bar/ hole along with hook like profile or step type L- profile for carrying the screening, everything connected and assembled through interlocks of SS316L material, to avoid too much head loss through the mesh is optimized.

Screen frames are heavy-duty duty made in SS316L and 5 mm thickness, horizontal tubular pipes are mounted inside frame and assembled properly.

The cleaning brush will be located in solid discharge, will be circular, and Brush hair shall be made of high-quality material with UV and chemical-resistant bristles and Neoprene or Polyurethane blades, cleaning system are activated by helicoidally gearbox with direct transmission, brush will be working always when screen is in working, alternatively a spray nozzle bars can also be given for cleaning of perforated panel on the discharge of screen in place of rotating brush.

C. Inspection Platforms

An inspection platform shall be provided for periodic checking and maintenance of the drive and other critical parts. A ladder with handrails for access to this platform shall be fixed. Suitable handrails shall be provided for safety on the inspection platform and also at deck level. The platform shall have holes to prevent rainwater accumulation.

D. Discharge Chute

A discharge chute shall be of minimum 4 mm thick provided for each screen to divert screenings discharged from the screen to a conveyor mechanism. The discharge chute shall be made of SS 316. The discharge chute shall be mounted at an angle of minimum 30 degrees. Panels are positioned on both sides to protect from splashing. Screenings are delivered down an enclosed chute. Two nos. Screening containers (wheeled) of suitable capacity shall be supplied with the screens.

E. Covers

Covers which are easily removable shall be provided for easy maintenance. Covers shall be constructed of clear impact-resistant Polycarbonate material thickness 6 mm and SS 316 thickness is 2 mm to allow for visual observation during screen operation.

F. Driving Mechanism

The driving mechanism shall consist of a sturdy reduction gear unit driven directly by an electric motor. A manually reset torque limiter shall be provided between the motor and gear unit, incorporating a limit switch to cut off the supply to motors in the event of an overload. The drive mechanism for the shall incorporate a solid shaft constructed of SS 316. The drive to the main shaft shall be TEFC weatherproof IP55 motor fitted with an anti-condensation heater. The motor shall be flanged to a shaft-mounted gear unit giving the final output speed. This shall produce a linear speed for the screen panels of about 3 m/min. The drive shall be protected from mechanical overload by an electrical current sensing device in the screen control panel. Suitable conveyer arrangement shall be provided to transfer the screenings to the nearest container/trailer. A spray system shall be provided to backwash the screen panels and to help in cleaning the screenings. Water / treated sewage shall be used for back wash purpose.

8.10.2 Installation

The screen shall be designed for installation to either (a) pivot out of the channel, (b) be pulled out of the channel. Non-metallic side flaps seal the screen to the channel walls, or (c) The Screen shall be grouted in a wall recess and/or floor recess. Minimum 600 mm access clearances between the screens shall be provided. And screens shall be designed in such way that minimal tools shall be used removal of screen Panels and covers during maintenance. The contractor shall maintain minimum spares parts such as brushes, nozzles, chain links and sensors.

8.10.3 Surface Finishing:

Stainless steel components shall be fabrication and then pickled and passivated on all surfaces to remove any ferrous contamination taking place during the process of welding, cutting, machining, and handling.

8.10.4 Gear Reducer

(a) The reducer shall be sized and selected with a minimum service factor of 2.0 times the motor nameplate horsepower rating in accordance with applicable American Gear Manufacturer's Association Standards. The reducer shall have a life of 40,000 hours based on the motor name plate horse-power. The reducer shall have an efficiency of not less than 90% based on reducer input.

(b) All gear meshes shall be oil lubricated. All gears shall be provided with an oil reservoir for instant lubrication on starting. The gear reducer housing shall be provided with an oil level indicator and oil drain with necessary fittings.

(c) The gear reducer shall be of cast iron construction. The reducer housing shall also include suitable lifting lugs and external gear train inspection covers for each gear train. The gears shall be matched for maximum tolerance variation. The gear reducer shall be suitable to reduce the motor asynchronous speed to achieve the required speed of raking.

8.10.5 Control System

(a) The screening operation shall be carried out through adjustable timers which are adjustable at site for 0-60 minutes for interval between the two operations (Screens & Conveyor).

(b) Control system for the conveyor shall be designed to achieve the following:

(i) Conveyor shall be started when any of the rakes starts its upwards travel.

(ii) Conveyor shall be stopped with a time delay (by adjustable timer) after rake is stopped.

(c) Weatherproof, lockable, emergency mushroom headed stop push buttons shall be provided near each motor for screen and screw conveyor Operation of stop push button, and overload prevention for screen and screw conveyor shall be included in the control scheme.

(d) The panel should be made of Stainless steel SS316 with IP-55 protection and comprise of Mushroom Head Emergency stop switch, Overload relays for motor protection, MCB's, HRC Fuses, Control circuitry to operate the screen with Differential radar type level sensors Selector Switch to operate the screen on clogging mode and this entire screen & conveyer system shall be operated in fully automatic modes of operation. Screen cleaning trigger shall be provided for every minimum 30 minutes even if no clog is detected to prevent biofouling. Also, the Alarms (Trip, Torque, motor overload & high, Low-water Level sensing etc..) as applicable shall be populated as Alarms to the Operator for further intervention ir-respective of any mode of operation.

(e) Variable Frequency Drive should be provided with panel.

Technical particular and MOC are listed in the table below:

Si.no.	**Technical Description**	**Data**
1.	Perforation size of screen Step/ Mesh or Plate	4 mm (maximum)
2.	Screen Mesh or Plate thickness	4 mm
3.	Top, Bottom & Side Plates	Minimum 5 mm thick
4.	Discharge chute	Minimum 4 mm thick
5.	Angle of Inclination	65 to 75 degree
	Material of construction	
a.	Screen Filter step/Mesh or Plate	Stainless Steel ASTM A 240, Grade 316L
b.	Screen Frame (Top, Bottom, Adjacent Sides and Dead Plates)	Stainless Steel ASTM A 240, Grade 316
c.	Drive Chain & Sprocket	Stainless Steel ASTM A 240, Grade 316L/ Duplex Stainless Steel SAF 2205
d.	Drive Shaft	Stainless Steel ASTM A 276, Grade 316
e.	All Fasteners and Anchor Bolts	Stainless Steel, Grade 316
f.	Discharge chute	Stainless Steel ASTM A 240, Grade 316

Si.no.	Technical Description	Data
g.	Spray bars & jet nozzles	Stainless Steel ASTM A 240, Grade 316L
h.	Dewatering tube	Stainless Steel ASTM A 240, Grade 316L

8.10.6 Controls And Instrumentation

A. General

i) Fine Screens

Sewage flow shall enter the inlet common channel of fine screens. The high-level in this channel shall initiate a screen cleaning cycle, and both the “Low” and “high-high” level shall generate an alarm.

The fine screens shall be operable manually by using Auto / Manual position control switch from a local control panel located adjacent to the equipment or remotely from the WwTP SCADA / HMI. Remote operation shall be operator selectable as manual or auto. In auto mode, operation of the screen rake mechanism shall be controlled by level differential with a timer override. Radar Type Level Sensors shall be installed both upstream and downstream of the screens. When the upstream minus downstream level differential reaches an operator specified maximum, a screen cleaning cycle shall be initiated. Alternatively, the operator may also specify a maximum interval between cleaning cycles (as Timer Setpoints configurable). If this interval elapses without cleaning, a cleaning cycle shall be initiated regardless of level differential. The speed of Screen drives shall be synchronized automatically by using VFDs during any clog situation to retain back to the original position with minimum number of iterations otherwise those drives shall be tripped automatically for further manual interventions. The upstream and downstream levels shall be continuously monitored by differential level measuring systems.

Alarms/faults and status shall be monitored/logged, and control commands shall be generated in accordance with the Engineer-approved I/O list (As per Typical Drive Control Philosophy table in Part-13).

ii) Screening Conveyer

The screening conveyer shall operate in Auto mode in linkage with the Fine screens. The screening conveyer can be operated manually by the operator at a local control panel located adjacent to the equipment for trouble shooting or maintenance, or at the WwTP SCADA / HMI.

Alarms/faults and status shall be monitored/logged, and control commands shall be generated in accordance with the Engineer-approved I/O list (As per Typical Drive Control Philosophy table in Part-13).

The entre screen & conveyer system shall be operated in fully automatic operational requirement. The conveyor drive trips when all screen drives under trip mode otherwise conveyor drive operation shall be continuously in Run mode. The Screen Control Panel embedded with internal wiring stand-alone PLC & 10 inches panel mounted touch screen HMI system which includes Potential free contacts / Terminal Blocks / Selector Position Control switches (Manual / Auto) and also entire Screen PLC / HMI data (Feedbacks & Command signals including Alarms) shall be interfaced with WwTP PLC / SCADA system by using hard wired communication system (Compatible protocol in line with WwTP PLC / SCADA System) for the purpose of continuous monitoring and control operations. For more details, please refer SCADA CONTROL SYTEM ARCHITECTURE DRAWING in Volume-4 of the tender document.

The control system shall be provided by the screen supplier.

B. LOCAL CONTROLS (PER SCREEN)

1. One (1) National Electrical Manufacturers Association (NEMA 7, 4-hole, Class 1 Division 1) approved Cast Aluminium local control station.

C. CONTROL PANEL

1. Manufacturer shall provide control panel with a lockable NEMA 4X corrosion-resistant stainless-steel enclosure for free standing. Contractor shall install the control panel and provide wiring.
2. Control panel shall contain all power and control devices necessary for the proper function of the screen and shall include the following:
   a. 600-Volt rated main circuit breaker disconnect with lockable handle
   b. 480 – 120 Volt control power transformer
   c. VFD and Circuit Breaker Branch Circuit Protection for main screen drive motor
   d. VFD and Circuit Breaker Branch Circuit Protection for screen cleaning brush motor
   e. Control Panel ON-OFF selector switch

f. MANUAL-OFF-AUTO selector switch for the operation of the screen drive

g. 3-pole reversing contactors with screw clamp terminals, motor protection relays and all other necessary equipment for screen motor and brush motor protection

h. “Screen Drive On” indication

i. “Brush Drive On” Indication

j. “Wash Water On” Indication

k. “Screen Motor Fault” indication

l. “High Water Level” indication

m. “Control Power” indication

n. Alarm silence and reset push buttons

o. Spare contact for remote indication of “Screen Motor Fault” alarm

p. Spare contact for remote indication of “High Water Level” alarm

q. Spare contact for remote indication of “Control Power Failure” alarm

r. Control relays, wiring and circuitry required to implement the control logic

s. Programmable controller (PLC) & Operator Interface (i.e. Panel mounted 10 inches touch screen HMI) makes shall be followed as per approved make list of PLC / Instrumentation in Part-13.

t. “Emergency-Stop Operated: pop-up with Alarm Indication

8.10.7 Screw Conveyor with compactor

(a) Technical specifications of Screening Conveyor

The Screening Conveyor shall be Shaft Screw Conveyor and applied for conveying the floating debris to the next facilities. The screening system shall be supplied with a shaft screw conveyor that will be used to convey the screenings to the automatic screenings press and discharge system that compacts, dewaters and discharges the screenings through a chute to the screenings storage system.

Dumping of the screenings on to the duty/standby conveyor opening shall be with the automatic deflection plate, which shall be positioned towards the conveyor which is selected from the LCP/SCADA for the duty and automatically towards the standby if duty conveyor trips. Position of this deflection plate shall be interfaced with PLC.

Screening wash compactor shall be suitable for washing and compacting the floating waste coming out of the duty and standby shaft screw conveyor in case of multiple screens, or directly from the screen in case of single screen installed in municipal waste water pumping station or treatment plant.

Shaft screw conveyor shall be made of stainless steel of grade SS 316 and shall incorporate shaft spirals. Cover plates for shaft screw conveyors shall be provided along the entire conveyor length to contain splatter. Conveyor trough covers shall be made from 5 mm of specified grade of stainless steel single piece formed sheet metal, not greater than 1000 mm in length, attached to the screw conveyor trough using toggle clamps. The cover shall also be of sufficiently tight fit to prevent the conveyed media from leaking out of the conveyors. A minimum 2.5 mm neoprene gasket of 50 durometer shall be applied with an appropriate adhesive to the mating surfaces of the trough covers.

Its structure shall have excellent durability to continuous running for long time. It shall be well taken into account of abrasion resistance, corrosion and vibration resistance. It should have a structure which is free from debris material clogging.

The spiral flighting for the shaft less screw conveyors shall be designed to convey material without a center shaft. The spiral flights shall be designed with stability to prevent distortion and jumping in the trough while operating at design speed and design capacity. The spiral flighting shall be Stainless steel of grade SS 316.

Shaft conveyor trough liner material shall be an ultra-high molecular (UHMW) polyethylene with a minimum 12 mm thickness. There shall be two colored layers in the liner material to indicate wear. The liner shall extend the full length of the trough, covering the entire semicircular bottom portion of the trough. The liner shall be secured at intervals not to exceed 1000 mm, using specified stainless steel retaining clips of an approved design.

Screening wash compactor shall be made of stainless steel of grade SS 316. The wash compactor will receive the waste through inlet hopper and the waste shall get dropped in to the conveying zone of the compactor main body.

Screw and liner shall have rigid thickness for resisting corrosion and abrasion caused during carrying of debris. Its structure shall be designed not to invite biting and clogging. Casing shall be equipped with inspection port to the necessity as well as for cleaning convenience. Driving device shall have overload limiting switch for avoiding broken situation caused by overloading.

The conveying zone shall have perforations at the bottom so that the water coming along with the wet screening is dropped into the dewatering trough. The dewatering trough will have a set of nozzles positioned upwards so that the screening particles chocking the perforations will be removed by the force of spray water. The construction of the dewatering trough shall be inclined towards the drive end so as to enable the flow of water to the drain hole provided with an elbow connection. The compactor main body shall also have a drain hole with an elbow connection.

In the conveying zone there shall not be any impeller wheel or any other mechanical breaking device. The breaking up of organic matter shall be done solely by water through an assembly of nozzles connected with solenoid valves in a special washing zone between the conveying and the compaction zone. The screening shall move towards the compaction zone by a shafted screw of a constant pitch connected to a drive shaft. This drive shaft shall be connected to the drive unit through axial and radial bearings. An electronic device shall operate the drive unit of the spiral in a forward reverse mode, separated by a stand still period. The time of forward and reverse operation as well as the stand still time shall be freely adjustable.

The non-drive end of the screw shall have the flight of reduced pitch in the compaction zone. For achieving better strength at non-drive end, the screw must be supported by wear bars connected to the wash press main body and reinforced with double flights of defined pitch.

An elephant trunk shape outlet tube shall be connected to the compactor body with a flanged connection. An elbow shall be provided at the flanged connection to carry the washed screening in the reduction tube. The reduction tube shall be divergent to ease the push of the washed screening upward into the outlet tube. The end of the reduction tube shall have an elbow with discharge plate/chute to enable the collection of the screenings in bagging units or a container.

The Screening wash compactor shall remove the organic material by washing and compaction thus reducing the volume and weight by 50%.

The main body of Screening wash compactor shall have a material thickness of minimum 3 mm and the bottom of the compactor main body shall be perforated with 5 mm holes.

The screw flights of wash compactor shall have a minimum thickness of 10 mm and at the end of compaction zone, there shall be wear bars of 10 mm thickness bolted to the wash press main body/tube for easy replacement.

The elephant trunk shaped outlet tube shall be diverging to prevent the waste getting clogged. The connection of the outlet tube to the main body shall be flanged type. All the bend fittings (elbows) in the outlet tube shall be long radius design.

Frequency Inverter shall be provided for Forward-reverse-forward motion of the screw and as overload protection device.

The gearbox of screw conveyor and wash compactor shall be hollow shaft, parallel helical gear unit have a minimum service factor of 1.2, oil bath lubricated with oil sealing. The motor shall be of TEFC type with minimum IP 55 protection & Class F insulation and be suitable for operation on 3 phase,

415V and frequency of 50 Hz. The drive shaft must be precisely machined and shall have radial and axial bearings.

The common control panel shall have IP 55 protection, painted with epoxy paint and shall be comprising of

- Mushroom head emergency stop.
- Overload relays for motor protection.
- Circuitry to operate the Screening conveyor and wash compactor with signal for start command from screen motor start and delay-timer based stop command after the screen motor stops.
- Selector switch to operate the Screening conveyor and wash compactor in Auto, manual and remote mode.
- Provision for suitable PLC circuitry shall be provided in case requirement of connectivity with SCADA system.

The Screw conveyor and wash compactor shall be supplied factory assembled and duly tested at manufacturer's works before dispatch. Upon receipt at site these shall be installed resting on the channel floor and mechanically or chemically anchored on to the platform in a way that there are minimum chances of misalignment.

Material of Construction

Screw	SS 316
Screw trough	SS 316
Screw cover	SS 316
Liner	Ultra-High Molecular Polyethylene (UHMPE)

Accessories

Anchor bolts and nuts	1 set
Special tools	1 set
Flexible joint for inlet and outlet	1 set
Liner (for spare)	1 set

8.10.8 Portable Screenings Container

Portable screenings containers made of galvanized steel shall be provided to store the screenings until time of pick up. Minimum two Screenings Containers shall be provided at the screening chamber. The container shall have capacity of approximate 2.0 cum. and shall be of a convenient height to permit the discharge of screenings directly into the container without having to transfer the screenings manually. The containers shall have hinged covers and their design shall permit their being lifted by an overhead hoist or packer truck. The container will have four wheels each of minimum 40 cm diameter, Tyre type. The maximum height of container including wheels shall be 66 cms. The sides shall be constructed of 12-

gauge steel. The bottom of container shall be made of 5 mm plate steel. The containers shall be reinforced with 50 mm x 50 mm x 5 mm angle.

8.11 Manual Medium Bar Screen for WWTP

(a) The screen shall be installed in inlet bypass channel to grit chamber.

(b) The aperture size of the screen shall be 10 mm and 50 angle of inclination.

(c) The screen shall be fabricated out of SS316 flats and fixing bolts shall be of stainless steel.

(d) The rectangular trash screens shall comprise SS 316, 10 mm thick and 50 mm wide in section.

(e) The screen shall be rigidly fixed to the frame.

(f) All the bypass screens shall be provided with 2 sets of SS 304 cleaning rakes with appropriate grip handle.

8.12 Manually Operated Travelling Crane

8.12.1 Crane

(a) The crane shall be manually operated for return activated sludge pumping station.

(b) The capacity of crane shall be as per the equipment list in particular mechanical requirement and of class II.

(c) The crane bridge shall consist of a single bridge girder carrying two wheels at each end of the span. Steel used shall be tested quality steel conforming to IS 2062.

(d) The long travel bridge wheels shall be rim toughened; heat treated galvanized carbon steel or low alloy steel or C.I. They shall be double flanged type. The wheels shall have antifriction ball/roller bearings. The wheels shall be machined on their treads to match the runway rail section. The bridge shall have a geared shaft and pulley connecting to opposite wheels of the span, to achieve the long travel motion of the bridge, by means of a chain. The runway rails of adequate strength and rigidity, rail clamps and other accessories for mounting the rails and suitable end stops for the bridge shall be supplied by the Contractor.

8.12.2 Trolley and Chain Pulley Block

(a) The chain pulley block shall be operated on the lower flange of the bridge girder.

(b) The load chain shall be made of alloy steel as per IS: 3109. It shall be heat treated to give ductility and toughness so that it will stretch before breaking. It shall be of welded construction with a factor of safety not less than 5.

(c) The hand chains, SS 316, for the hoisting and traverse mechanism shall hang well clear of the hook and both the chains shall be on the same side. The hand chain wheel shall be made from pressed sheet steel and shall be provided with roller type guarding to prevent snagging and fouling of the chain.

(d) All the gearing shall be totally encased. Proper lubricating arrangements shall be provided for bearings and pinions. Gears shall be cut from forged steel blanks. Pinions shall be of heat treated alloy steel. Gears shall be as per BS 436/IS: 4460.

(e) The trolley track wheels shall be rim toughened, heat treated carbon steel or alloy steel and shall be single flanged and shall have antifriction ball bearings. The wheels shall be machined on their treads to match the flanges of the track joints.

(f) The travelling trolley frame shall be made of rolled steel conforming to IS: 2062. The side plates of trolley frame shall extend beyond wheel flanges, thus providing bumper protection for the wheels. The two side plates shall be connected by means of an equalizing pin.

(g) Axles and shafts shall be made of carbon steel and shall be accurately machined and properly supported.

(h) The lifting hooks shall be forged, heat treated alloy or carbon steel of rugged construction. They shall be of single hook type provided with a standard depress type safety latch. They shall swivel and operate on antifriction bearings with hardened races. Locks to prevent hooks from swiveling shall be provided. Hook shall be as per BS:2903/IS:3815

(i) The brake for the lifting gear shall be automatic and always in action. It shall be of screw and friction disc type self-actuating load pressure brake. Brakes shall offer no resistance during hoisting.

8.13 Electrically Operated Hoists

(a) Electric hoists shall be complete with hoisting motor, wire rope drum, wire rope, hook, necessary gearing, sheaves, electromagnetic brake for hoisting motion, weather & dust-proof push button station, contractor panel, all wiring, limit switches, etc.

(b) Electric hoists shall conform to IS: 3938 and shall be suitable for outdoor application. All the parts of the hoist shall be designed to withstand surrounding atmospheric conditions without any deterioration.

(c) Rope drums shall be either cast or welded to sustain concentrated loads resulting from rope pull. Drums shall be machine grooved right and left with grooves of a proper shape for the rope used.

(d) Gears shall be cut from solid cast or forged steel blanks or shall be of stress-relieved welded steel construction or built-up from steel billets and welded together to form a one piece gear section. Hoist ropes shall be extra flexible, improved plough steel rope with a well lubricated hemp core and having six strands of 36 wires per strand with minimum ultimate tensile strength of 1.6 x 106 KN / Sqm.

(e) Hooks shall be solid, forged, heat treated alloy or carbon steel of rugged construction of the single hook type and provided with a standard depress type safety latch.

(f) Hoisting motor shall be equipped with electrically released, spring set, friction shoe type brakes having torque capable of holding 125% of the full rated hook load. Brake shall apply when either the motor controller or the main power switch is in ‘OFF’ position or in the event of power failure.

(g) Drive motors shall be designed for frequent reversal, braking and acceleration and shall be as per IS: 325. Pendant control switch, controllers and resistors, controls, electrical protective devices, cables and conductors, earthing guards etc. shall be as per IS:3938. Limit switches shall be provided for over-hoisting and over-lowering.

(h) The electric hoists shall be of Class II duty.

(i) 25% overload test, speed tests, limit switch tests and brake test shall be conducted for the hoist and trolley at manufacturer’s works.

(j) Minimum Two sets. of sufficient slings, ropes, shackles, lifting beams, etc, shall be supplied to handle all items of plant covered by the crane. They shall be labelled or marked with the Safe Working Load (SWL) and the purpose for which they are intended.

8.14 Hand Operated Hoists and Trolleys

(a) Manual hoists shall be complete with hand-chain, trolley, pulley block, hook, hand and load chains, brake and other accessories. They shall comply with the latest applicable standards, regulations and safety codes in the locality where equipment will be installed.

(b) Each hoist shall be operated on a monorail (I-Beam). The factor of safety shall not be less than 5. The load chain may be heat-treated to give ductility, toughness and conforming to I.S. 3109/B.S.1663/B.S.3114. The load wheel is to be made from heavy duty malleable castings. The hand chain is to Conform with B.S. 6405 and hand chain wheel may be made from pressed sheet steel with roller type guarding. Gears shall be cut from solid cast or forged steel blanks or shall be stress – relieved welded steel construction.

(c) Pinions shall be of forged carbon or heat treated alloy steel. Strength, Quality of Steel, heat treatment, face, pitch of teeth and design shall confirm to BS-436, BS-545 and BS-721. Spur and helical gears must comply with B.S. 436 and worm with BS 721. Bearing must be ball and roller type conforming to I.S. 2513/B.S., 2525-32.

(d) Proper lubricating arrangements are to be provided for bearings and pinions. The brake for the lifting gear shall be automatic and always in action.

(e) The proof testing of each chain pulley block is to be carried out as per latest applicable standards. The safe working load is to be marked in such way that is clearly visible from the operating level.

(f) Minimum Two sets. of sufficient slings, ropes, shackles, lifting beams, etc shall be supplied to handle all items of plant covered by the crane. They shall be labelled or marked with the Safe Working Load (SWL) and the purpose for which they are intended.

8.15 Electrically Operated Overhead Travelling Crane

(a) The crane shall be electrically operated, bridge type complete with all accessories including down shop conductor, crane rails and fixtures, and shall conform to BS 2573, IS:3177 or relevant internationally approved standards.

(b) The crane bridge shall consist of bridge girders on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel. Access walkway with safe hand railing as is required along the full span length of the bridge girder. Steel shall be tested quality conforming to ASTM A36 except that, plates more than 20 mm thick shall conform to IS:2062, BS:4360 or relevant internationally approved standards.

(c) The bridge shall be designed to carry safely the loads specified in IS: 807, BS: 2573 or relevant internationally approved standards. All anti-friction bearings for bridge and trolley track wheels, gear boxes and bottom sheaves on hook shall be lubricated manually by hand operated grease pump through respective grease nipples.

(d) Wheel base and structural frame of the wheel mounting of the end carriages shall be designed so as to ensure that the crane remains square and prevent skewness. Bridge and trolley track wheels shall be of forged steel and shall be double flanged type. The wheel diameter and rail sizes shall be suitable for the wheel loads.

(e) The crane rails shall be manufactured from wear resistant austenitic manganese steel. Mountings of the wheels shall be designed to facilitate easy removal for maintenance. Walkways shall be at least 500 mm clear inside width with a 6 mm thick non-skid steel plate surface. Steel rail stops to prevent rails from creeping and trolley from running off the bridge shall be abutted against ends of rails and welded to the girders. Bridge and trolley stops to match the wheel radius shall be provided before the buffer stops.

(f) All exposed couplings, shafts, gear, wheels, pinions and chain drives etc. shall be safely encased and guarded completely to prevent any hazard to persons working around. All bearings and gears shall have a design life of 100000 hours. Electro-magnetic and hydraulic thrust or brake shall be provided for the main hoist. One electro-magnetic brake shall be provided for each of the cross travel and long travel motions.

(g) Hook shall be solid forged, heat treated alloy or carbon steel suitable for the duty service. They shall have swivels and operate on ball thrust bearings with hardened races. The lifting hooks shall comply with the requirements of IS 8610 or BS: 2903 / BS: 3017 or relevant internationally approved standards and shall have a safety latch to prevent rope coming off the hook.

(h) Hoist rope shall be extra flexible, improved plough galvanized steel rope with well lubricated hemp core and having six strands of 36 wires per stand with minimum ultimate tensile strength of 1.6 X 10^6 kN/m2 of Right Hand Ordinary (RHO) lay construction. The ropes shall have a 6:1 safety factor on the specified safe working load, and shall conform to IS: 2266. Rope drums shall be grooved and shall be either cast iron or cast steel of or welded steel conforming to IS:3177, BS:466 or relevant internationally approved standards.

(i) Gears shall be cut from solid cast or forged steel blanks or shall be stress relieved welded steel construction. Pinions shall be of forged carbon or heat treated alloy steel. Strength, quality of steel, heat treatment, face, pitch of teeth and design shall conform to BS:436, IS:4460 and BS: 721 or relevant internationally approved standards.

(j) Name Plate showing the capacity, year of manufacture and rated capacity of hoist in figures not less than 150 mm height shall be placed on each side of the crane girder.

(k) The maximum deflection under full load shall not exceed 1/900 of the span (as per IS: 3177).

(l) All accessory and auxiliary electrical equipment including drive motors, electrically operated brakes, controllers, resistors, conductors, insulators, current collectors, pendant push button station, protective devices, operating devices, cables, conduits, etc. necessary for the safe and satisfactory operation of the crane shall be provided. (Power to the crane shall be provided by down shop conductors manufactured from high conductivity hard drawn copper. Conductors shall be completely shrouded such that they have no exposed current carrying surfaces.

Pendant type push button station shall be sheet steel enclosed and shall comprise the following push buttons and indicating lamps:

(i) `Start' and `Stop'.
(ii) Long travel - `Right' and `Left'.
(iii) Cross travel - `To' and `Fro'.
(iv) Hook - `Hoist' and `Lower'.
(v) Red indicating lamp for supply `ON' indication.

(m) Pendant type push button shall be supported independently of the electrical cable and shall be earthed separately, independent of the suspension. Automatic reset type of limit switches shall be provided to prevent over travel for each of the following:

(i) For `UP' and `Down' motions of the hook.
(ii) Long travel motion
(iii) Cross travel motion

(n) Crane structures, motor frames and metal cases of all electrical equipment including metal conduit and cable guards shall be earthed. All motors, brakes, limit switches, panels, drum controllers, resistor unit sets shall be provided with two studs for earthing.

(o) The crane, and all slings, ropes, shackles and other lifting equipment supplied shall be tested by the manufacturer at his works. The tests shall be carried out at 125% of Safe Working Load, and Test Certificates shall be supplied.

(p) All motors shall be of the quick reversing type with electric mechanical brakes suitable for the duties specified. All movements shall be electrically powered suitable for operating with the hook loaded. Facilities shall be provided for the accurate location of the hook by means of `inching' the cross travel and down shop travel motions.

(q) Minimum Two sets. of sufficient slings, ropes, shackles, lifting beams, etc shall be supplied to handle all items of plant covered by the crane. They shall be labelled or marked with the Safe Working Load (SWL) and the purpose for which they are intended.

(r) The Contractor shall include with the cranes all necessary contactors, control cubicles and protection equipment necessary to operate the crane and provide adequate electrical protection against overload, phase and earth fault and fail-safe protection in the event of an interruption in the power supplies. All access ladders and platforms necessary to carry out maintenance and repairs shall be provided and installed by the Contractor.

(s) All electrical equipment shall be fully tropicalised.

(t) Site tests shall be carried out by the Contractor who shall supply the necessary materials for the test load. The test load shall be removed from site by the Contractor after successful tests have been carried out.

8.16Jib cranes

Fixed Jib Cranes shall be provided for each clarifier in the lowering/removal of equipment/parts to/from the clarifier floor and transferring the same outside the clarifier area. The Jib Crane capacity shall be 1.25 times the maximum weight to be handled in the clarifier or 2.0 Tonnes whichever is maximum.

The lift and reach of the cranes shall be suitable for the clarifier offered. The crane shall be capable of being swivelled by 360°.

All materials used in the construction shall be corrosion resistant. Mild steel used shall be galvanised. Ropes, chains and pulleys shall be of stainless steel construction. Hardware shall be of SS 316.

8.17 COMPACT Pre-Treatment System (COMBI Unit)

A. Scope of Supply

Combi units are used for pre-treat wastewater before introducing the wastewater treatment plants. They perform fine screening with a Screening conveyor and compactor, and Grit removal with a Grit washing system and grease removal system. All these treatments are performed on a single equipment.

The inflow streams at first passes through a rotary drum screen (with 4 mm spacing) installed in the first chamber which removes all the floating and suspended material. The screenings are discharged directly from the screen after transport and compaction in an integrated screenings press. In the following chamber of longitudinal grit trap, settleable material is separated through the reduction of flow velocity. The plant shall be equipped with grit trap aeration for removal of Fat, Oil and Grease. A horizontal shafted screw conveyor transports the separated solids (grit and organic particles) against flow direction to a grit classifying shafted screw which is integrated at the beginning of the grit trap. During their transport in the grit classifying screw the solids are statically dewatered prior to being discharged into a container. Compact Inlet Head works includes Rotary Drum screen/Band or perforated punch holes Screening system with conveyor system and an Optimal Coarse Bubble Aerated Grit diffuser system to avoid adverse effects on downstream treatment facilities with blower arrangement with Conveyor system in a Single fabrication unit which shall be installed on the RCC Platform with necessary staircase with proper access approach.

Incoming pumping main from Terminal Sewage Pumping Station (TSPS)/Intermediate Sewage Pumping Station (ISPS) shall be connected to the inlet of Combi Unit and Outlet shall be connected to Aeration Basin/SBR Basin/MBBR Tank/IFAS Tank system.

B. Constructional Features

The complete plant shall consist of units inclusive of longitudinal grit trap, fine rotary drum screen, screw conveyors for removal, transferring and dewatering the screenings and grit in shafted design.

Longitudinal grit trap shall be equipped with the provision of removal of Fat, Oil and Grease by means of aeration by Rotary Air blowers.

Compact system shall be fabricated by using minimum 8 mm SS 316 plates with reinforcement Angles, Channels and necessary Gazette plates sufficient thickness shall be welded to have robust and compact design and construction. Lifting hook/Lugs shall be welded for lifting the entire unit from ground level to the top of the RCC Platform. Total combi unit shall be anchored with proper grouting material (GP2) shall be used to avoid the vibration on the platform. Combi unit shall be supplied with minimum one standby unit. Combi unit shall be placed on the Platform with sufficient spacing between the two units adjacent to access each unit for regular operation and maintenance. Access platform of minimum 1.5 m shall be provided all around the units with handrailing.

Complete plant shall be prefabricated structure SS316 except the drives, motors. The plant shall be designed and fabricated so as to connect with the incoming sewer pipe my means of a flange connection.

Similarly, the outlet of the plant shall be connected to the downstream treatment process via flange connection.

The rotary drum screen basket should be a precisely welded construction. The perforated plate/ wedge wire surface which retains the screenings should be welded onto a supporting structure. Spirals of metal strips on the inner drum surface transport the screenings upwards and drop them into the trough. A brush fitted to the inner drum surface cleans the trough edge as the basket rotates. The screen basket at the bottom end is to be fixed to the screw by means of a strut, while on the upper end support is to be provided with several rollers. A brush or a polyurethane sealing on the baffle plate is to be used to seal the gap between the screen basket and channel.

C. Operation and Functional Features:

The machine starts when the screen level control level (or any other start signal) is reached. The screen drive motor operates as long as the start signal is active and transports the solids out of the channel. The water level in front of the screen falls again. The screen running time must be individually adjusted to each plant by programming a (selectable) follow-up time.

If the inflow is low, screenings may accumulate in front of the screen if screen starting is not effected via screen level control. To prevent accumulation of screenings, a time can be programmed after which the screen drive motor is necessarily switched on after a selectable standstill time. The screen drive motor will then operate according to the freely programmable follow-up time.

To protect the screen against mechanical damage, the electrical control is to be equipped with an overload relay. The machine stops immediately whenever the overload relay responds. After a pause of 2 seconds the screen drive motor is reversed for a programmable time. To avoid damage of the bottom shafted screw flight screen reversal has to be limited. This applies also to manual operation, i.e., even in manual mode the screen can only be reversed for the pre-defined time even if the key or button is operated longer. A new reversal is only possible after prior forward operation.

As soon as the start signal from the level control system responds, the machine starts to run forwards again after a waiting time of 10 seconds.

If the overload relay trips 3 times within 5 minutes, the machine is stopped, and a trouble is reported. The machine can only be re-started after reset of the fault.

If the Overload relay trips during screen reversal, the machine must immediately be stopped. A fault message is reported. The machine can only be re-started after reset of the fault.

If the current relay trips during screen operation in manual mode (forwards or reversal), the machine must immediately be stopped, and a fault message reported. The machine can only be re-started after reset of the fault.

The scope of supply shall include the Combi Unit with all accessories and appurtenances, including, but not limited to:

1. **Fine screen (4 mm) with screen conveyor with Compactor**

Mesh Band or Punched hole Screen Detail specification shall be same fine Screen specification as specified in the Part 8 Cl.no. 8.10.

2. **Screen Washer system**

Screen washer system as Spray nozzle bar shall be provided for cleaning of screen basket. A solenoid valve is to be provided to control the washing operation. The solenoid valve is controlled parallel to the forward operation of the screen motor drive. While the screen basket rotates, screenings are removed by means of the flat jet nozzles. Press zone washing system is to be provided. Activation of the press zone washing system effects cleaning of the press zone and press liquor collection chamber. For this purpose the solenoid valve for press zone washing is to be provided. The integrated screenings washing system shall

be provided to wash out the faces contained within the screenings and return them to the biological process. Such screenings washing improves screenings dewatering efficiency.

Washing system consist of three washing stages: preliminary washing, washing with pressure, fine washing, Preliminary washing / washing with pressure is carried out by water supply via the solenoid valve. Fine washing: Three washing units on the rising pipe are connected with pressure hoses, The nozzles spray in an exactly defined angle onto the screenings while these are conveyed by the screw. Water supply is via a second solenoid valve on machine and bigger which is controlled separately (solenoid valve for fine washing). Tank cleaning system is to be provided for cleaning of the tank with solenoid valve.

3. Grit removal system with Grit washing system and Grease removal system

The Retention time for Grit and grease removal should be 2.5 minutes and above. For aerated plants a grease trap shall be provided. Floating particles are carried over to the attached grease trap more or less with the air roll of grit trap aeration. The grease is to be removed intermittently by an integrated grease paddle.

Wastewater flows into the grit removal zone, where the finer solids materials are still present in the wastewater are settled in the tank with the introduction of air, and the same has been conveyed to the hopper by a horizontal screw conveyor which is installed for grit removal conveys the grit particles in to a Grit washing system.

The Grit washing system is used to separate the grit and clean grit (sand, gravel) from wastewater, removing organic matter and preparing it for further processing or disposal. The cleaned grit is then discharged via a screw conveyor to a discharge bin or container, while the washed-out organics are typically returned to the wastewater flow.

The grease paddle ensures uniform removal of grease over the entire grease trap surface. The grease paddle pushes the grease into a collection chamber at the beginning of the plant from where it is pumped by an eccentric screw pump. For aerated grit traps, Rotary Lobe blower is to be provided for aeration. The individual air tubes can be adjusted to specific site requirements via separate ball valves.

System has a blower integrated and coarse bubble diffusers and a scum cleaning and removal device that contains air to prevent the rotary cleaner from clogging, grease are generated and forced to corner where a water nozzle system are moving and pushing grease to a rotary scraper which will concentrate and eliminate grease discharging it by gravity pipe into container. A Grease removal unit is integrated into the system to remove the oil and grease in the incoming sewage water. System have a blower integrated and coarse bubble diffusers, grease are generated and forced to corner where a water nozzle system are moving and pushing grease to a rotary scraper which will concentrate and eliminate grease discharging it by gravity pipe into container.

4. Discharge Chute

A Discharge chute stainless steel 316 shall be provided at the discharge part of the screw conveyor. The chute shall be constructed such that the screenings are blocked from being discharged.

5. Screw Conveyor with compactor

Technical specifications of Screening Conveyor

The Screening Conveyor shall be Shaft Screw Conveyor and applied for conveying the floating debris to the next facilities. The screening system shall be supplied with a shaft screw conveyor that will be used to convey the screenings to the automatic screenings press and discharge system that compacts, dewaters and discharges the screenings through a chute to the screenings storage system.

Dumping of the screenings on to the duty/standby conveyor opening shall be with the automatic deflection plate, which shall be positioned towards the conveyor which is selected from the LCP/SCADA for the duty and automatically towards the standby if duty conveyor trips. Position of this deflection plate shall be interfaced with PLC.

Screening wash compactor shall be suitable for washing and compacting the floating waste coming out of the duty and standby shaft screw conveyor in case of multiple screens, or directly from the screen in case of single screen installed in municipal wastewater pumping station or treatment plant.

Shaft screw conveyor shall be made of stainless steel of grade SS 316 and shall incorporate shaft spirals. Cover plates for shaft screw conveyors shall be

provided along the entire conveyor length to contain splatter. Conveyor trough covers shall be made from 5 mm of specified grade of stainless-steel single piece formed sheet metal, not greater than 1000 mm in length, attached to the screw conveyor trough using toggle clamps. The cover shall also be of sufficiently tight fit to prevent the conveyed media from leaking out of the conveyors. A minimum 2.5 mm neoprene gasket of 50 durometer shall be applied with an appropriate adhesive to the mating surfaces of the trough covers.

Its structure shall have excellent durability to continuous running for long time. It shall be well considered of abrasion resistance, corrosion and vibration resistance. It should have a structure which is free from debris material clogging.

The spiral flighting for the shaft screw conveyors shall be designed to convey material without a center shaft. The spiral flights shall be designed with stability to prevent distortion and jumping in the trough while operating at design speed and design capacity. The spiral flighting shall be Stainless steel of grade SS 316.

Shaft conveyor trough liner material shall be an ultra-high molecular (UHMW) polyethylene with a minimum 12 mm thickness. There shall be two colored layers in the liner material to indicate wear. The liner shall extend the full length of the trough, covering the entire semicircular bottom portion of the trough. The liner shall be secured at intervals not to exceed 1000 mm, using specified stainless steel retaining clips of an approved design.

Screening wash compactor shall be made of stainless steel of grade SS 316. The wash compactor will receive the waste through inlet hopper and the waste shall get dropped into the conveying zone of the compactor main body.

Screw and liner shall have rigid thickness for resisting corrosion and abrasion caused during carrying of debris. Its structure shall be designed not to invite biting and clogging. Casing shall be equipped with inspection port to the necessity as well as for cleaning convenience. Driving device shall have overload limiting switch for avoiding broken situation caused by overloading.

The conveying zone shall have perforations at the bottom so that the water coming along with the wet screening is dropped into the dewatering trough. The dewatering trough will have a set of nozzles positioned upwards so that the screening particles chocking the perforations will be removed by the force of spray water. The construction of the dewatering trough shall be inclined towards

the drive end so as to enable the flow of water to the drain hole provided with an elbow connection. The compactor main body shall also have a drain hole with an elbow connection.

In the conveying zone there shall not be any impeller wheel or any other mechanical breaking device. The breaking up of organic matter shall be done solely by water through an assembly of nozzles connected with solenoid valves in a special washing zone between the conveying and the compaction zone. The screening shall move towards the compaction zone by a shafted screw of a constant pitch connected to a drive shaft. This drive shaft shall be connected to the drive unit through axial and radial bearings.

An electronic device shall operate the drive unit of the spiral in a forward reverse mode, separated by a stand still period. The time of forward and reverse operation as well as the stand still time shall be freely adjustable.

The non-drive end of the screw shall have the flight of reduced pitch in the compaction zone. For achieving better strength at non-drive end, the screw must be supported by wear bars connected to the wash press main body and reinforced with double flights of defined pitch.

An elephant trunk shape outlet tube shall be connected to the compactor body with a flanged connection. An elbow shall be provided at the flanged connection to carry the washed screening in the reduction tube. The reduction tube shall be divergent to ease the push of the washed screening upward in to the outlet tube. The end of the reduction tube shall have an elbow with discharge plate/chute to enable the collection of the screenings in bagging units or a container.

The Screening wash compactor shall remove the organic material by washing and compaction thus reducing the volume and weight by 50%.

The main body of Screening wash compactor shall have a material thickness of minimum 3 mm and the bottom of the compactor main body shall be perforated with 5 mm holes.

The screw flights of wash compactor shall have a minimum thickness of 12 mm and at the end of compaction zone, there shall be wear bars of 10 mm thickness bolted to the wash press main body/tube for easy replacement.

The elephant trunk shaped outlet tube shall be diverging to prevent the waste getting clogged. The connection of the outlet tube to the main body shall be flanged type. All the bend fittings (elbows) in the outlet tube shall be long radius design.

Frequency Inverter shall be provided for Forward-reverse-forward motion of the screw and as overload protection device.

The gearbox of screw conveyor and wash compactor shall be hollow shaft, parallel helical gear unit have a minimum service factor of 1.2, oil bath lubricated with oil sealing. The motor shall be of TEFC type with minimum IP 55 protection & Class F insulation and be suitable for operation on 3 phase, 415V and frequency of 50 Hz. The drive shaft must be precisely machined and shall have radial and axial bearings.

The common control panel shall have IP 55 protection, painted with epoxy paint and shall be comprising of

- Mushroom head emergency stop.
- Overload relays for motor protection.
- Circuitry to operate the Screening conveyor and wash compactor with signal for start command from screen motor start and delay-timer based stop command after the screen motor stops.
- Selector switch to operate the Screening conveyor and wash compactor in Auto, manual and remote mode.
- Provision for suitable PLC circuitry shall be provided in case requirement of connectivity with SCADA system.

The Screw conveyor and wash compactor shall be supplied factory assembled and duly tested at manufacturer’s works before dispatch. Upon receipt at site these shall be installed resting on the channel floor and mechanically or chemically anchored on to the platform in a way that there are minimum chances of misalignment.

Accessories

Anchor bolts and nuts	1 set
Special tools	1 set
Flexible joint for inlet and outlet	1 set
Liner (for spare)	1 set

6. Portable Screenings Container

Portable screenings containers made of galvanized steel shall be provided to store the screenings until time of pick up. Minimum two Screenings Containers shall be provided at the screening chamber. The container shall have capacity of approximate 2.0 cum and shall be of a convenient height to permit the discharge of screenings directly into the container without having to transfer the screenings manually. The containers shall have hinged covers and their design shall permit their being lifted by an overhead hoist or packer truck. The container will have four wheels each of minimum 40 cm diameter, Tyre type. The maximum height of container including wheels shall be 66 cms. The sides shall be constructed of 12-gauge steel. The bottom of container shall be made of 5 mm plate steel. The containers shall be reinforced with 50 mm x 50 mm x 5 mm angle.

The system will have an Odour enclosure to treat as a meeting Odour intensity to a level that minimizes adverse effects on the living environment at Near the exhaust duct outlet of the deodorizing device with the pipe in the screen zone, grit/grease tank, and sand washer.

a) Material of Construction

The material of construction of the Combi Unit shall be grade 316L stainless steel and an Odour control system, a Carbon filter shall be FRP Vessel.

b) Corrosion Resistance

All metal parts of the screen equipment that are in contact with the sewage shall be constructed of a suitable grade of corrosion-resistant stainless steel 316 L, and odour gases of FRP vessel and ducting.

c) Performance criterion

90 % of grit removal for particle size ≥ 0,2 mm, Specific gravity of grit particle shall be 2.65

d) Motor Specifications

Premium efficiency class (IE3 and above), with IP55 Protection, Nominal voltage 415V±10% and nominal frequency 50 Hz, Design ambience temperature shall be 45 Degree Celsius.

e) Working Stress and Design

The design of all parts shall ensure that under the most onerous of conditions, they will not be damaged or corroded. Any joint that will need to be dismantled during maintenance shall be made with anti-corrosion type fasteners. All spare parts shall be fully interchangeable with the original part. If the spare part is unavailable due to cessation of production, the Contractor shall give notice to the Employer in writing, detailing the options available to the Contractor.

All parts shall be designed to minimize the risk of fire and consequential damage. All parts shall be designed to prevent the ingress of vermin, dust, and dirt. All electrically live or moving parts shall be adequately guarded to prevent accidental contact.

f) Outlet Guarantee Parameters of Combi Unit

Sl. No.	Parameters	Value
a)	Dry solids content in debris	Up to 30%
b)	Waste volume reduction	Up to 50%
c)	Waste weight reduction	Up to 60%
d)	Grit removal efficiency for particles > 0.200mm (200 Microns) > 0.100mm (100 Microns)	 90% 85%
e)	Final dewatered grit from the Grit washer	< 3% on dry basis
f)	H2S Outlet of OCU	< 0.5 ppm

g) Material of construction:

Sl. No.	Item Description	Particulars
A	**Compactor Tank**	
i.	Material Of Construction with Partitions inside the Tank	Minimum 8 mm SS 316 plates with reinforcement Angles, Channels, and necessary Gazette plates
ii.	Tank Structure with Partitions	Rectangular with Hopper Bottom
iii.	Inlet and Outlet connection	SS 316, Flanged type (PN 10 Rating)
iv.	Opening size	Pipe Diameter equal to incoming Pumping main size
v.	Top Cover for Odour Control unit	SS 316 Plate with minimum 5 mm thick, Odour control unit Flange connection on the top cover
vi.	Overflow Pipe	Overflow Pipe provision with DI piping upto nearest drain Point
B	**Screen and Compactor**	
i.	Fine Screen Type	Automatic Rotary Drum Screen or Punched Hole/mesh Fine Screen
ii.	Screen Opening size	4 mm (Maximum)

Sl. No.	Item Description	Particulars
iii.	Screen Mesh or Plate thickness	Minimum 4 mm
iv.	Top, Bottom & Side Plates	Minimum 5 mm thick
v.	Discharge chute	Minimum 4 mm thick
vi.	Screw Conveyor type	Shafted or Shaftless both are accepted
vii.	Drum/Screen Cleaning	By Brush fitted on Spiral or Water Spray jet type by Plant Water or Motorised Brush cleaning for Fine Band/Mesh Screen
viii.	Rotation Speed	6 RPM (Maximum)
ix.	Geared Motor Voltage/Frequency/Degree of Protection/ Insulation type	415V/ 50Hz/ IP55/ Class F
x.	**Material of construction for Rotary Drum Screen**	
a.	Screw Conveyor with wash compactor	SS 316
b.	Drum / Punched/ Mesh Plate	SS 316
c.	Channel Sealing and Drive Shaft	SS 316
d.	Water Nozzle	SS 316
e.	Brush	Nylon
xi.	**Material of construction for Mesh Band/Punched Hole Fine Screen**	
a.	Screen Filter step/Mesh or Plate	Stainless Steel ASTM A 240, Grade 316L
b.	Screen Frame (Top, Bottom, Adjacent Sides and Dead Plates)	Stainless Steel ASTM A 240, Grade 316
c.	Drive Chain & Sprocket	Stainless Steel ASTM A 240, Grade 316L/ Duplex Stainless Steel SAF 2205
d.	Drive Shaft	Stainless Steel ASTM A 276, Grade 316
e.	All Fasteners and Anchor Bolts	Stainless Steel, Grade 316
f.	Discharge chute	Stainless Steel ASTM A 240, Grade 316
g.	Spray bars & jet nozzles	Stainless Steel ASTM A 240, Grade 316L
xii.	**Screw Conveyor and Compactor**	
a.	Screw	SS 316
b.	Screw trough	SS 316
c.	Screw cover	SS 316
d.	Liner	Ultra-High Molecular Polyethylene (UHMPE)
C	**Areated Grit System and Grease Removal unit**	
i.	Blower Type	Rotary Lobe Blower
ii.	Installation Location	At Ground Level Near to the Inlet Head Works with proper RCC Building
iii.	Capacity and Pressure	As per vendor Recommendation

Sl. No.	Item Description	Particulars
iv.	Areated Grit Piping	Coarse Bubble type with 5 mm Pore size (maximum)
v.	Material of Construction of piping	SS 316 L with minimum Schedule 40S Seamless
vi.	Pipe Supports for Air Piping	SS 316 L
vii.	Grit Conveyor and Screw Classifier	Shafted or Shaftless both are accepted
viii.	Material of Construction of Grit Conveyor and Screw Classifier	
a.	Screw	SS 316
b.	Screw trough	SS 316
c.	Screw cover	SS 316
d.	Liner	Ultra-High Molecular Polyethylene (UHMPE)
ix.	Geared Motor Voltage/Frequency/Degree of Protection/ Insulation type	415V/ 50Hz/ IP55/ Class F
x.	Settling Tank at end of unit	Partition within the compactor unit with Effluent Outlet SS 316, Flanged type (PN 10 Rating)

Provide the membrane fixed to the membrane holder in a manner which does not introduce unbalanced stresses and increases sealing pressures as the air flow rate to the diffuser risers.

~~Provide a back flow prevention device built integrally with the diffuser that prevents backflow into the diffuser and air piping.~~

~~Provide an airflow control orifice to ensure even airflow distribution among all diffusers. Ensure that the airflow to any one diffuser is within plus or minus 5% of the average value, at all airflows.~~

~~Provide a maximum diffuser flux rate such that the stress in the diffuser material is within elastic loading limits with a safety factor of at least 10. Submit test results, calculations, and any other documentation to exhibit that the membrane material will be able to withstand operating loads without undue stress or strain leading to failure in compression or shear, or creating significant mechanical creep of the material which would impair functioning or would cause enlargement of the membrane perforations or holes.~~

~~Provide the tolerances of the diffusers and the diffuser mounting bases such that any diffuser and any gasket may be assembled onto any mounting base and provide a seal capable of withstanding the applied hydrostatic and/or pneumatic head.~~

~~Provide diffusers mounted by the action of a threaded component that shall require measurement of the applied torque to the threaded component during tightening. The torque measurement shall lie within the range of torques specified by the diffuser equipment supplier.~~

~~Provide diffuser material resistant to chemical attack, UV light, weathering and aging. Submit test results, certifying the integrity of the membrane. Provide data indicating the susceptibility of the membrane material to attack by various chemicals.~~

~~Provide all rubber components manufactured from synthetic rubber materials proven to be resistant to corrosion, degeneration or abrasion in the environments proposed.~~

~~Provide diffusers capable of withstanding a maximum differential pressure of 30 kPa and a maximum air temperature of 80˚C. Provide protective storage of rubber and plastic components of diffusers prior to installation.~~

~~Provide effective cover to the diffusers after installation to protect them against physical damage and the ingress of dust and dirt before filling the new Tanks with water.~~

~~The fixed diffuser arrangement system should provide equal distribution in the aeration basin and there should not be any dead zones in the basin. Diffusers should be installed at equidistant intervals and shall be anchored & grouted with SS 316 fasteners and SS 316 clamping arrangement.~~

~~Complete diffuser grid piping shall be assembled at original factory and site fabrication of diffuser is not acceptable.~~

~~Furnish all components necessary to provide a complete mixing and aeration system. Work shall include but not necessarily be limited to the following:~~

~~Flanged connections (SS 316) at the upstream side of each drop leg for connection to an isolation double flanged metal seated Butterfly valve Gear operated.~~
~~Stainless steel Drop legs (SS 316).~~
~~Slip joint connections to the air distribution header (SS 316).~~
~~Stainless steel Air distribution headers (SS 316).~~
~~Diffuser connectors (SS 316).~~
~~Anchored Supports (SS 316) as necessary.~~
~~Gaskets.~~
~~Header joints (SS 316).~~

~~Bolts, nuts and washers (SS 316).~~

~~The Diffusers should be able to withstand high blower air and water temperature.~~

~~The air pressure that discharges oxygen / air into the sewage shall be generated as air bubbles that overcome the depth of tank and loss resistance of the diffusers.~~

~~The main cause of blockage of the diffusers due to solid matter is that when the oxygen supply to the aeration tanks is stopped, the inside of the air pipe instantaneously becomes negative pressure, and then, water depth pressure is applied, so MLSS water passes through the holes in the diffuser to pipe as backflow to the diffusers and its's pipe.~~

~~On the other hand, when bubbles are released from the air diffusers, a swirl flow shall be generated near the surface of the diffusers, so that the sewage may be slightly caught in a hole near the surface of the diffuser.~~

~~The sludge water that has entered the diffuser pipe shall remain in the inner surface of the air supply pipe / inside the diffuser, and some of solids is not removed even when the compressed air supply is resumed. Due to compressed high temperature air (about 60-80 ° C), the deposit becomes dry solid and causes clogging and this may lead to cases where the installed membrane diffuser may bust.~~

~~In order to extend the service life of the diffusers and reduce repair costs, the structure of diffuser shall be excellent in durability, does not clog, maintains high dissolution efficiency, and ensures easy replacement work.~~

~~The performance conditions of the Tubular type aeration shall be minimum performance guarantee for damage, clogging, and dissolution efficiency of the diffuser is 5 years.~~

~~Contractor shall provide back flow prevention mechanisms / check valve inside each diffuser. This is to prevent intrusion of liquid and/or solids into diffuser and air piping under normal operating conditions of aeration system.~~

~~- Diffuser Assembly~~

~~Provide orifice flow control to ensure orifice head loss is at least 2.5 times the head loss in the air header at all air flow rates in the diffuser's design operating range.~~

~~Air Header and Drop legs~~

~~Header and drop legs shall be constructed of 316 stainless steel.~~

~~1. Bottom elevation of the air distribution header shall be same throughout the tank.~~
~~2. Design connections between sections of the air distribution header to allow individual header sections to rotate independently of adjacent header sections.~~
~~3. Header dimensions shall conform to dimensional tolerances specified in ASTM A554-89 and ASTM A530-87.~~

Furnish a drop leg from the air main connection at the top of the tank.

1. Provide a slip joint connection between the drop leg and distribution header.
2. Support the drop leg from the connection at the air header.

Use factory welding only; field welding shall not be allowed.

1. Wire brush outside of each weld area.
2. Remove all discoloration and deposits left by welding by pickling.
3. Factory weld all diffuser connections. Stiffen both the diffuser connectors and the headers to withstand a moment of 56.5 Nm. at the connector without permanent deformation.

Passivate all SS 316 assemblies and parts after fabrication by immersion in a pickling solution of 6 percent nitric acid and 3 percent hydrofluoric acid at 60° C for a minimum of 15 minutes.

1. Neutralize by immersion in a tri-sodium phosphate rinse.
2. Submit certificate that this has been done.

Supports and Anchors

Provide wall and floor mounting supports for all drop legs and air headers as necessary to anchor firmly on the wall and to the bottom of the tank and as specified herein.

Anchor supports to concrete walls and floors using stainless steel expansion bolts sized and spaced as required for the loads encountered.

Design supports to allow leveling the air header and diffuser assemblies to within specified tolerances.

Provide expansion couplings in the drop legs and air headers as necessary to accommodate anticipated thermal expansion and contraction.

1. Submit expansion coupling design as well as computations for sizing.

Spare Parts

Provide spare parts in the quantities indicated.

Item	Quantity
Diffuser Assemblies	5%
Orifice Inserts	5%

The Spare part shall be maintained/repurchased at all times during O&M period.

Installation

Install all components in accordance with the manufacturer's instructions and recommendations.

Install all diffusers to within +/- 10 mm of a common horizontal plane.

Air supply Pipe Work

General design Criteria

Many factors need to be incorporated in the design of the air distribution pipe work to minimize the potential of noise problems occurring. Factors to be considered in the design of the air pipe work to be minimize noise level shall include:
The diameter of the pipe work, to keep velocity low.
The connection of the blower discharge pipes to the manifold should be "Y", not at right angles.
No blind flange at the end of the manifold.
The manifold shall be designed to ensure air travels in one direction.
The air pipe work shall be designed to minimize changes of direction and use large radius bends.
Flexible connections shall be provided between the diffuser assembly units and the main air supply pipe work to allow for any differential movements.
Expansion and contraction shall be fully allowed for in the design and installation of the air distribution pipe work.
Rain taps shall be provided on the air pipe work to allow draining of moisture.
The pipe work and the support brackets shall be galvanized steel.
Pipe work shall have inbuilt flexibility such as packer flanges for reasonable construction tolerances on the structures to which it is attached.
In addition, consideration should be given to fixing piping materials that can withstand the compressive heat of air and shrinkage pressure of piping caused by direct sunlight.
If the pressure in the piping is negative due to a decrease in compressed air pressure due to the stop of aeration, a check valve should be considered.

Pipe shall be designed to ensure the efficient operation of the aeration system and compliance with the noise limitations. All valves in the air delivery system shall be correctly selected for the duty. Calculations of Cv (Head loss co-efficient) values for the range of flows and pressure losses across each valve should be prepared to ensure that each valve has adequate range of controllability for the duty.

However, the air piping submerged in sewage has to be in SS316 confirming to IS specification. Two spare drop pipes shall be supplied by the operator one for each compartment. This will be used to replace the choked diffusers drop pipe or on preventive basis on rotation. The choked one will be attended to and used as spare drop pipe.

Air supply Headers

The air supply headers run from the main air distribution pipe work to the down comers. Pipe work shall have inbuilt flexibility such as packer flanges for future modifications and to allow for reasonable construction tolerances on the structures to which it is attached. An isolation valve for each main air supply pipe shall be installed at the point of connection to the main distribution pipe work. The design of the main air supply header shall incorporate all components necessary to enable the easy connection of the main distribution pipe work to the main air supply header.

Blower Discharge Pipe Work

The Discharge pipe work from each blower shall be connected to a common manifold. Flexible connections shall be provided between the blower assembly units and the discharge pipe work to allow for any differential movements. The

design of the manifold pipe work shall incorporate all components necessary to enable the easy connection to the main distribution pipe work.

Air Flow Measurement

The amount of air being supplied to each air supply header shall be measured by the installation of flow measuring devices. The flow measuring devices shall be suitable for the intended application. The sensor assembly shall be supplied with suitable fittings which shall enable easy removal during maintenance. The accuracy of the flow meter shall be within 5% of the minimum design flow rate. The installation shall provide adequate length of straight pipe upstream and downstream of the flow meter to ensure the accuracy of the meter is attained. Pressure and temperature sensors shall be provided to measure the pressure and temperature of the air in the pipe, upstream of the flow meter device.
Pressure and temperature compensation measurements shall be provided for volumetric correction if the control air is based on airflow rate.

High Speed Turbo Blower

Turbo blowers are single-stage, high speed gearless air cooled radial turbo blowers designed to meet varying flow and pressure requirements in various processes. The system shall include factory assembled high speed turbo blower with a modern frequency controlled, gearless driven machine along with lubricant free aerodynamic/Permanent magnet bearings, guarantees an economical, reliable and maintenance-free operation.

Turbo Blowers employ the high precision machined cast impellers, hydrodynamic air foil/Permanent magnetic bearings (air-lubricated), highly efficient Permanent Magnet motors and sensor-less Invertor drives, which eliminate the complicated gear trains or pulley & belt to provide considerable energy savings without much scheduled maintenance and with very low level of noise. Acoustically enclosed unit with noise not exceeding 85 dBA at distance of 1.86 meter from periphery of the Blower unit with sufficient air windows.

A. Permanent Magnet (PM) Motor

The Blower shall be driven with Permanent Magnet motor. The rotor of the motor has built in permanent magnet, the power is required only to rotate the shaft. With the rotor being specifically designed to rotate at high speed, the size of the rotor is small. Rotor shall be of titanium & inconel alloy is lighter in weight. Because of these two factors the twisting torque is comparatively very small. The high electric grade material & high rotating speed produce less heat & hence cooling energy required is PM Motor shall be synchronous motor, which has no slip & hence power factor shall be high. The efficiency is consistently maintained more than 95% from full load to partial load conditions. The PM motor is entirely air cooled and capable of a wide range of operating speed. Integrated variable speed drive ensuring starting current of the PMS motor to be less than 10% of the full load current. Current (Ampere) based active control should be used to enable high rise to surge.

B. Frequency Inverter

The frequency inverter, DC choke and RFI filter are standard and integrated in the Turbo Blower package. Other types of harmonic filters shall be supplied as per site conditions.

C. Air Foil Bearings

Air bearings shall not come in any physical contacts when shaft is in motion, which doesn't require any lubricant. The Air Foil bearings are of aerodynamic bearings. At standstill (idle mode) the shaft sits on a foil tightened by springs. During operation, due to shaft rotation a cushion of air is generated between the foil and shaft which maintains the shaft in suspension without any need for an external source of compressed air. This increases energy efficiency. The bearings are not lubricated, and the system is absolutely oil-free.

D. Impeller & Casing

The impeller is directly mounted on the shaft of the motor. The impeller is made up of machined cast stainless steel having high structural strength /Aluminum alloy material. The profile is backward leaning to provide larger flow capacity, wide operating flow range & high efficiency.

The impeller alone is first dynamically balanced & again dynamically balanced together after mounting on the shaft. The spiral casing and the blower bell mouth are made of cast aluminum, while the discharge connection is made from Stainless steel.

E. HMI Display

HMI display indicates the Discharge Pressure, Inlet Temperature, Discharge Temperature, Flow Rate, Power consumed, Speed and the across the inlet filters. It shall also displays the performance curve with the actual operating point in it. HMI Touch Screen Graphical Display with on-line performance curve showing Pressure v/s Flow, Operating Point.

HMI should provide on-line display of instantaneous values & trending of following parameters: Pressure Drop across Suction Filters, Suction Air Temperature, Discharge Air Temperature, Discharge Air Pressure, Input Power & Dissolved Oxygen; RPM, Run Hours with facility for MODBUS connectivity to SCADA to display these parameters. Facility for remote control of pressure, flow, power, D.O. parameters shall also be provided. Integrated Mass Flow Meter for instantaneous on-line flow measurement with +/- 1% accuracy.

The following operation mode can be selected from HMI.

a. Constant Current

b. Constant Pressure

c. Constant Volumetric Flow

d. Constant Oxygen (Dissolved Oxygen Control)

F. Acoustical Enclosure

(a) Provide a factory assembled acoustical enclosure around the entire blower. Disassemble the enclosure as necessary for shipment. Provide either removable or hinged doors for access to all blower parts and components for servicing and maintenance. Size access panels to allow easy access by a single operator. Hinges, fasteners and appurtenances shall be stainless steel. Provide clear, transparent Lexan or plastic windows to visually observe gauges. Installation of insect repellent net at the louvers.

(b) Mount an auxiliary exhaust fan and thermostat on the acoustical enclosure to provide air circulation after blower shutdown or when the temperature inside the enclosure exceeds 40°C.

(c) The free field A-weighted sound pressure level measured in four quadrants at 1.86 metre distance from the enclosure shall average 85 dBA, or less. Measure with a Type 1 instrument suited for checking compliance with Environmental and Occupational Noise Rating Recommendations.

All the accessories shall be complied as per specification mentioned in Centrifugal single stage blower.

Material of Construction:

Si.no.	**Description**	**Material of Construction**
a	Blower Housing, Motor Housing	High Strength Aluminium alloy material
b	Impeller	Stainless steel having high structural strength /Aluminum alloy material
c	Shaft	Alloy steel with Permanent magnets/Titanium
d	Base plate	MS Profiled steel
e	Inlet filter, silencer casing	Hot Dip Galvanised Steel Sheet
f	Acoustic enclosure	Al-Zn coated steel, insulated with glass wool
g	Blow-off silencer and motor cooling silencer	Hot Dip Galvanised Steel Sheet
i	Inlet cone extension	Hot Dip Galvanised Steel Sheet
j	Coupling	Alloy Steel
k	Air Foil/Magnetic Bearing Body, Cooling Fan	High Strength Aluminium alloy material
l	All connecting accessories and anchor bolts	AISI 316

8.18.1 Centrifugal single stage Blower:

a) The blower shall be of single stage centrifugal and shall be designed integral type. The flow rate should be adjustable by controlling the rotation speed with frequency converter according to the inlet temperature and differential pressure to ensure the optimal power consumption. Regulation should be possible in the range of 100-50% of the specified design flows at all project design temperatures and at design pressures.

b) The regulation should be fully automated and contain a program for continuous optimization of blower efficiency with respect to changes in inlet temperature, differential pressure and required flow.

c) The pressure grade of the blower casing shall be minimum PN10. The casing shall be cast and bolted together and allow the impeller to be removed with the casing in situ.

d) The impeller shall be open radial flow type (with backward leaning) and made of aluminium alloy, all surface of the vanes should be finish machining.

e) High frequency, variable rotation speed and air cooling motor should be adopted. The impeller and cooling fan should be directly connected with the motor shaft.

f) The motor shall be equipped with magnetic bearings (If required), which should have the characteristic of magnetic suspension and continuous variable rotation speed. The motor should be installed at a frame with flexible fastening devices.

g) Two radial magnetic bearings and one axial magnetic bearing shall be orientated accurately via the active bearing controller controlling the rotor. The active bearing controller shall be powered by one DC and one 3 phase AC input. The service life of all bearings should be more than 100000 hours.

h) Appropriate cooling arrangement shall be provided at the blower discharge line so as to bring down the outlet air temperature within tolerable limits, so as to safeguard the life of fine bubble diffusers and satisfactory performance of the same. This cooling arrangement is mandatory with all types of Blowers.

i) The local control cabinet should be equipped with display screen and keypad unit. The running state of the blower should be able to monitor at real time. The displayed data at least include the following:

- Actual flow (%)
- Running time (hour)

- Running time (day)
- MWh counter
- Differential pressure
- Reference flow (%)
- Model of the blower
- Power frequency of the motor (Hz)
- Current (A)
- Transition temperature
- Motor temperature

j) When operating, if the control system finds fault, the blower will give an alarm automatically or stop and the fault code will be displayed at the control cabinet. All signals can be transferred to the control centre of the plant.

k) The blower should have the following protection functions (but not limited to):

- Over voltage of the main power supply
- Under voltage of the main power supply
- I-phase fault
- Over voltage/Under voltage of the auxiliary power supply
- Inlet and outlet air pipe blocking
- Air temperature is higher than the specified limited temperature
- Cooling air temperature is high than the specified limited temperature.

Accessories

a) Inlet filter and silencer:

Each blower shall be provided with an inlet filter/silencer mounted directly on the inlet of the Blower via a flexible connection. Such mounting is for the purpose of reducing pressure drop across the inlet appurtenances and of minimizing noise from pipes. Filter/silencer housing shall consist of stainless steel plate and acoustical sound deadening material on the inside. Installation of insect repellent net at the louvers.

Filters shall be removable through easily accessible doors and have very high removal efficiency and shall be sized for maximum face of velocity of 2 m/sec at peak air flow.

b) Discharge Flex Connector:

Each blower shall be provided with discharge expansion Bellows joint of SS316. The expansion joint shall alleviate stress caused by thermal expansion and contraction in the piping system. The expansion joints shall be capable of withstanding the pressure under all operating conditions and shall be rated for temperatures up to 160°C.

c) Discharge Cone Diffuser Silencer:

Each blower shall be supplied with a combined discharge cone diffuser-silencer to increase the discharge from the blower outlet to the discharge pipe, thus reducing the air velocity to max. 16 m/sec. The length of the discharge cone shall be aerodynamically designed in order to recover dynamic pressure head and minimize discharge turbulence. The discharge cone shall be constructed of stainless steel plate and acoustical sound-deadening material on the inside, with flanges, and be equipped with a stud for a possible measuring device.

d) Blow-off (Bypass) Valve:

Each blower shall be provided with a blow-off valve to allow unloaded start-up and unloaded stop. The valve operator shall be motorized, equipped with open/closed limit switches, and shall be suitable for air service at 200°C operating temperature. Controls for the valve shall be mounted in each local blower control cabinet with indicating light.

e) Blow-off silencer:

Blow-off silencer shall be provided for each blower and mounted on the discharge by-pass line. The blow-off valve silencer shall be constructed of stainless steel and contain sound absorption material encased in an outer shell. The silencer shall have one sleeve inlet connection for mounting onto the end of the bypass line.

f) Discharge check valve (Back-flow Barrier):

Each blower shall be provided with one discharge check valve flange ends located in the discharge side pipe work, spring loaded butterfly design for mounting between flanges according BS EN 1092-1/BS: 4504. The pressure losses of the fully open valve must not exceed 1.0 kPa. The valves shall be rated for temperatures up to 160°C.

g) Noise Protection Cover:

The blower and motor should be covered with one Acoustic cover, which should be equipped with electric cooling ventilator.

h) Base plate and anchor bolts:

Each blower unit shall be furnished with a frame of adequate size to support the blower, motor, magnetic bearing controller frequency converter, control cabinet and other accessories. The base plate shall be constructed of fabricated steel, provided with lifting lugs and of sufficient rigidity to permit lifting by a fork lift, with all equipment mounted, without distortion or other damage to the base plate or to components parts of the machinery.

Material of Construction:

Si. No.	**Description**	**Material of Construction**
a	Blower Housing & Gear Box	CI IS 210 Gr. FG 260
b	Impeller	Stainless steel having high structural strength /Aluminium alloy material
c	Shaft	Carbon Steel (High Tensile) EN 19
d	Base plate	MS Profiled steel
e	Inlet filter, silencer casing	Hot Dip Galvanised Steel Sheet
f	Acoustic enclosure	Al-Zn coated steel, insulated with glass wool
g	Blow off silencer and motor cooling silencer	Hot Dip Galvanised Steel Sheet
i	Inlet cone extension	Hot Dip Galvanised Steel Sheet
j	Coupling	Alloy Steel
k	Air Foil/Magnetic Bearing Body, Cooling Fan	High Strength Aluminium alloy material
l	All connecting accessories and anchor bolts	AISI 316
m	Base plate	MS Profiled steel

Control

The control system of the blower should be well connected with the control system of the whole plant. All the real time monitor and protection function shall connect with the control software; the remote control shall be carried out with 4-20 mA or network.

Local control panel and control cabinet shall be combined, that include display screen and keypad, main switch and lock stop push button. The blower operation shall be controlled by the main running switch and keypad.

Performance Guarantee:

The Performance of the compressor shall be guaranteed according to the requested project design values subject allowed tolerances on Flow & Pressure: +/- 0%, and Power: 2%.

Compressor or any portion thereof is liable for rejection, if it fails to give any of the guaranteed performance parameters.

8.18.2 Submersible Mixer

A submersible mixer shall be used for mixing aerobic tank and anoxic tank in order maintain the oxygen Free State condition. An underwater mixer reduces stirring efficiency and overloads when the amount of tangled impurities in the sewage increases with the propeller. If the amount of tangled impurities in the sewage increases with the propeller, the mixing efficiency decreases and overload operation occurs. When the current values increases, it is necessary to remove impurities.

(a) The submersible mixer shall be installed in the specified plant areas, and they shall be capable of providing a velocity gradient in the range of 500 to 1000 mm/sec. Select a model that can mix sewage and sludge efficiently and uniformly. The mixers and power supply cables should have excellent water tightness and abrasion resistance.

(b) The mixer shall have a self-cleaning propeller optimized for effective mixing and vibration-free running, and required power shall be at least 10Watt/m^3 of tank volume.

(c) The mixer shall be driven by a submersible high efficiency 3 phase motors IP 68 Class F/H. Motor shaft and rotor shall be dynamically balanced.

(d) Bearings shall be lubricated for life with a calculated life of more than 100,000 operating hours.

(e) Power supply cable shall be secured such that it is not affected by the mixing flow, cutting with a stirring propeller or deflection.

(f) The mixers shall have the flexibility to be located at different depths and thereby avoiding dead zones. And fixing of the mixer at the bottom of the tanks it should not affect the sediment and mixing flow.

(g) The mixer shall be provided with the following :

(1) Lifting frame with a winch which can be dismantled, free standing with adjustable boom length.

(2) Mounting socket for free standing hoist suitable for wall mounting.

(3) Guide for floor fixing components and support brackets for wall mounting.

(4) Stainless steel (SS316) rope for raising and lowering the mixer.

(5) Rope block for holding the stainless steel 316 rope where the lighting frame is used in different locations.

(6) Support rope for reliable support and guidance of power supply cable.

(7) Support clamps and hooks to support the power supply cable in such a manner that it is not under strain.

(8) The propeller, and motor housing, guide pipe, support brackets and all fasteners shall be of SS 316. The propeller shaft shall be of SS 431/SS 420.The Lifting winch & Davit shall be of Stainless Steel 316 construction.

8.18.3 Rotary Air Blowers

(a) Compressor blowers shall be of the rotary tri lobe positive displacement type, each provided with inlet filter and silencer, pressure reducing valve, pressure gauges, pressure relief valve, drain, air flow indicator and acoustic bend or silencer in the delivery branch. Bearing housings and gear boxes shall be separated from the blower housings by air spaces. The units shall be complete with a self-contained oil cooling system for the bearings. The blowers shall be housed inside acoustic enclosure. The noise level shall not exceed 85 dBA at 1 meter from the Blower.

(b) The bearings shall be generously designed to give long operational life. Bearings at the drive end may be oil or grease lubricated. The gears and bearings at the non-drive end shall be oil lubricated. Bearings shall be provided with oil throwers to prevent leakage of oil. The blower shall be arranged for horizontal inlet and vertical outlet, delivery velocity not exceeding 16 m/s and each blower shall be provided with following components but not limited to:

(1) Common base frame for Blower & Motor.
(2) Inlet silencer and filter, with inspect replant net to avoid insect entry.
(3) Discharge Silencer & non return valve in delivery branch.
(4) Motorised Butterfly valves in both inlet and delivery branches with metal to metal sealing.
(5) Pressure relief valve or excess pressure safety device.
(6) Bellows SS 304 type couplings on inlet and delivery piping & on suction & delivery silencers.
(7) Acoustics Enclosure.
(8) V Belt drive arrangement with Belt Guard.
(9) Isolating valves, Pressure reducing valves & Pressure gauges
(10) Air Flow meters, Temperature gauges.
(11) Water trap.
(12) Gravel filter.
(13) Blower piping individual delivery pipe shall be provided dummy flange extension with pipe spool on opposite side of common header to reduce the noise level.
(14) After cooler arrangement for each blower on outlet side.

(c) The interconnecting pipe work shall be flanged to BS EN 1092-1/BS: 4504. A drain cock shall be provided at the lowest point in each delivery pipe work along with reflux valve. Individual stop valves and safety valves shall be provided for each unit.

(d) Blowers shall be driven by squirrel cage motors through a matched V-belt drive. Motors shall be mounted on slide rails mounted on a common bed plate, to facilitate the tensioning of the belts. Blowers shall not run above 1000 rpm and prime movers also.

(e) Each delivery branch shall include a drain at the lowest part and a reflux valve.
Each blower shall contain one inlet air pressure, one discharge air pressure, and one discharge air temperature gauge. The pressure gauges shall be calibrated in kPa absolute and be of the compound type. The gauges shall have circular dials, minimum 100 mm diameter with black figures on white background. Pressure gauges shall be furnished with pulsation damper. Temperature gauges shall be manufactured with standard temperature bulb.

(f) Appropriate after cooling arrangement for each blower shall be provided at the blower discharge line so as to bring down the outlet air temperature

within tolerable limits, so as to safeguard the life of fine bubble diffusers and satisfactory performance of the same. This cooling arrangement is mandatory with all types of Blowers after cooler shall be preferably shell and Tube type.

	Description	**Material of Construction**
a	Blower Housing	CI IS 210 Gr. FG 200 or 220
b	Lobes	CI IS 210 Gr. FG 200 or 220
c	Shaft	Carbon Steel (High Tensile) EN 19
d	Base plate	MS fabricated Epoxy Painted
e	Inlet filter, silencer casing	Galvanised Steel
f	Acoustic enclosure	Al-Zn coated steel, insulated with glass wool
g	Blow-off silencer and motor cooling silencer	Galvanised Steel
i	All connecting accessories and anchor bolts	AISI 316

8.18 8.18

Acoustical Enclosure

Provide a factory assembled acoustical enclosure around the entire blower. Disassemble the enclosure as necessary for shipment. Provide either removable or hinged doors for access to all blower parts and components for servicing and maintenance. Size access panels to allow easy access by a single operator. Hinges, fasteners, and appurtenances shall be stainless steel.

Provide clear, transparent Lexan or plastic windows to visually observe gauges and lever arms.

Mount an auxiliary exhaust fan and thermostat on the acoustical enclosure to provide air circulation after blower shutdown or when the temperature inside the enclosure exceeds 40°C.

The free field A-weighted sound pressure level measured in four quadrants at 1 metre distance from the enclosure shall average 85 dBA, or less. Measure with a Type 1 instrument suited for checking compliance with Environmental and Occupational Noise Rating Recommendations.

SBR System – General Requirements

(a) General

~~The vendor/supplier of the SBR system shall be completely responsible for the proper design of their system in full compliance with all requirements of the bid documents. The SBR system shall include but not be limited to: basin influent and other valves and actuators, diffused aeration equipment, Process air blowers, Waste activated sludge (WAS) transfer pumps, mixers/Selector zone with Coarse bubble diffusers, Decanters, and all other ancillary equipment and controls necessary for a fully functioning SBR system.~~

~~The SBR process and cycle time design shall incorporate true quiescent batch settling and a dedicated decant/wasting phase. Designs that allow influent flow/filling or include any other feature that compromises true quiescent batch settling during the settling or decant phase will not be permitted.~~

~~(b) Mixing and Aeration Performance~~

~~The SBR mixers shall be submersible mechanical mixers or by means of Selector zone with Coarse bubble diffusers. SBR mixers shall be designed to ensure complete mixing of the entire basin contents at all operating depths between the minimum and maximum depths, without the introduction of air. The mixing energy and velocities shall be sufficient to ensure complete and uniform solids suspension and dispersion, without any "dead pockets" of low velocities or settling or accumulation of solids.~~

~~The aeration system shall be designed to provide adequate oxygen transfer to the contents of each SBR basin during the aeration phase, in accordance with minimum requirements specified elsewhere in these bid documents. Complete mixing and uniform distribution of air throughout the basin shall be achieved. This may be achieved with or without the simultaneous use of mixers during the aeration phase. For mixing-limited aeration systems, i.e., systems where the biological process air requirements at any operating condition are lower than air requirements for complete mixing, upsizing of the aeration system to provide required mixing will not be permitted. Such systems shall be designed to use the mixing and aeration systems together to simultaneously meet the mixing and aeration requirements.~~

~~Decanters (For SBR system)~~

~~(a) General~~

~~SBR decanters shall be floating or electro-mechanically positioned with subsurface withdrawal and a positive solids and scum exclusion mechanism. Each decanter shall be capable of withdrawing decant effluent from 4 to 6 inches~~

~~beneath the liquid surface, regardless of liquid depth, down to the minimum design operating level. Decanters shall employ positive mechanical type seals or substantially similar mechanisms for excluding solids, scum, and any floatables from the effluent.~~
~~Site fabrication of decanters shall not be acceptable.~~

~~A telescoping valve shall be provided in each basin for periodic removal of scum and floating material. For electro-mechanically positioned decanters that pass through the surface layer to decant, the decant phase of each cycle shall be preceded by a skimming phase that shall fully and completely remove all scum and floating material from the vicinity of the decanter such that, when the decanter is positioned for decant, no scum is trapped between the decanter's weir and scum baffle.~~

~~All wetted components of the decanter assembly shall be constructed of 316L stainless steel including Piping. No effluent boxes or concrete mounting structures internal to the basin will be allowed. The wall pipe and embedment shall be designed to safely accommodate all loads transmitted by the decanter assembly under all operating and maintenance conditions.~~

~~All the withdrawal SS 316L Pipes shall be of thickness not less than Schedule 20S above 200 mm and Schedule below 200 mm shall be of Schedule 40S, and all the pipes shall be of Seamless type only.~~

~~The decanters shall be designed to mount to an appropriately sized cement mortar lined and coal tar epoxy coated ductile iron flanged pipe embedded in the SBR basin wall.~~

~~(b) Decant Flow Control Valve~~

~~An appropriately sized electrically operated butterfly flow control valve or through sluice gates & Stop logs shall be provided in the effluent pipe for each decanter to control the decant rate. All effluent flow control valves shall be located outside the walls of the SBR basins. If flows are received through the channels in such case provision shall be made to isolate each SBR basin using Sluice gates or Stop logs to take of preventive maintenance.~~

~~(c) Supports~~

~~For floating decanters, a complete support system/structure shall be provided to safely support the entire decanter assembly when the basin is drained. The support system shall be rigidly anchored to the basin floor. All concrete~~

embedded components (such as anchors) of the support system shall be 316L stainless steel. The other components shall be 316L stainless steel.

IFAS (Integrated Fixed film Activated Sludge) Treatment

The Fixed Film Activated Sludge system shall be designed to encourage attached growth of biomass on the fixed media and limit the suspended solids in aeration tanks as per CPHEEO. Addition of this system shall increase the biomass inventory in the aeration tank, through attached growth process. A Knitted fabric with growth surface strips with supporting loops made of flat fabric curtain sheet having density around 0.90g/cm3 is immersed into a basin in which biological growth also takes place in suspension. The media then provides a surface for the growth of attached biomass. Biomass attachment in the media shall not exceed 55 grams per m2 length of active surface area This combination of attached biological growth and suspended biological growth is a more efficient wastewater treatment system because there is an increase in the overall active biomass volume for a given system. Total biomass (Suspended + Attached) in the system shall not exceed greater than 4500 mg/l

IFAS design shall ensure sufficient BOD and TSS removal while encouraging nitrification of ammonia in the aeration tank. The system should be made up of bio-textile sheets aligned in metal cages. The fixed film media needs to be of polypropylene knitted curtains mounted on SS 316 cages. The IFAS Curtain shall be 100% Polypropylene yarns. The clamps and fixing accessories shall be of water resistant PP.

The fixed IFAS curtain media should be arranged parallel into the direction of flow. There shall be no
double wrapping/strings of textile on cages. The fixed film system shall use discreet, parallel textile
sheets on the cage. Rigid media shall not be allowed. Bio-textile sheets shall be knitted fabric with growth surface strips. The maximum specific growth surface shall be 25 m2/m2 design. Maximum active surface co-efficient shall be ≤ 0.65.

The systems shall require low maintenance and shall be a high energy efficiency system. It shall
not use any suspended media to avoid media loss. Further, the fixed film system shall be

provided in conjunction with high efficiency fine bubble diffuser mounted underneath of IFAS cages in aeration tank. The diffusers shall be spread throughout the basin to provide uniform aeration. Coarse bubble aeration shall not be acceptable.

8.18.15.1 Testing of IFAS system

All inspection and testing shall be carried out in accordance with relevant Indian Standard and in absence of IS as per Detail Tender Specification or internationally approved equivalent standard. The strip diffuser system shall have the capability to transfer the specified amount of oxygen at standard conditions, Standard Oxygen Transfer Rate or SOTR at standard conditions (14.7 psia, 20° C, zero dissolved oxygen) at the side water depth and maximum allowed air rate and pressure specified below.

Submit clean water test data from prior tests performed or witnessed by independent test organizations to demonstrate the capacity of the proposed equipment to meet the specified oxygen requirements. Tests shall have been performed in test tanks or process basins and shall be witnessed by an independent third party knowledgeable about clean water test procedures.

8.18.15.2 Diffuser system for IFAS

Fine Bubble Diffuser Detail to be used for IFAS shall be as per the below requirement, only fine bubble PU membrane diffusers shall be acceptable with minimum membrane diffuser to floor coverage area of 8%. Diffusers shall be submerged fine bubble / fine pore, high transfer efficiency, low maintenance, non-buoyant type. Diffusers shall be strip (membrane) type. Material of construction for (entire under water system including accessories shall be of non corrosive Complete diffuser as a unit shall be assembled at the manufacturing factory level. The grid supports shall be made of SS 304.

8.18.15.3 Type of Diffuser System

A fine bubble diffused aeration system shall be applied to aeration tank for oxygenation. The number of diffuser elements can be varied by the bidder depending on the manufacturer selected, subject to the condition that sufficient design calculations are attached along with it and the manufacturer is a standard

one having supplied the diffusers to various wastewater treatment plants of similar nature in the installing country.

8.18.15.4 Diffuser Elements

The diffuser elements shall be membrane type and resistant to such ingredients as hydrocarbons, oil and grease. This shall afford a high oxygen transfer rate coupled with a minimal pressure drop besides permitting simple erection onto the horizontal air manifold.

They shall have minimal coupling / attachments to the air manifold and shall have self-cleaning
properties while in action. Flat surfaces facing upwards as membrane surfaces shall only be accepted. The diffuser unit shall be of corrosion resistant material. The membrane diffusers shall permit connection to the air manifolds of circular or square cross section and the entire lot of diffusers shall be capable of discharging designed flow of air at an average flow (maximum of summer and winter requirement) with the nominal air flow per diffuser per element shall not exceed 80 m3/h/m2 of diffuser surface area when installed in the said aeration tanks.

The diffuser grid shall be of fixed type. The headers onto which the diffusers are fixed shall be of standard Imported PE/PVC/UPVC pipe sections of suitable inner bore and shape with custom fixtures of the diffuser elements as directed by the membrane manufacturers. Alternative pipe materials shall be acceptable provided the same are a mandatory part of the diffuser supplier and the sub-headers have enough counterweight or alternative arrangement to surmount any buoyancy lift from the floor during air charging.

The diffusers shall be fixed to bioreactor floor, Fine Bubble Diffused Aeration membrane diffusers with a maximum flux through the diffusers not exceeding 80 m3/m2 membrane area. The air from the blowers which shall have high temperature and should be cooled suitably to avoid damaging the diffuser membranes.

The material of diffuser and associated fixtures shall be:
Diffusers Membranes -PU Membranes
Diffusers Membranes Support -Engineering plastics Non-Corrosive material

Under water Air Piping to diffusers- UPVC/PE

Air downers to underwater pipe - UPVC/PE

The in-tank diffuser piping shall be sized for a velocity less than 21 m/sec.

8.18.15.5 Testing for Diffuser system

All inspection and testing shall be carried out in accordance with relevant Indian Standard and in absence of IS as per Detail Tender Specification or internationally approved equivalent standard at Manufacturer's Work.

8.18.15.6 Air Piping to Diffusers

SS Air headers are to be provided to avoid corrosion and the consequent damage to the fine bubble diffusers. System should allow acid injection and relaxation to ensure proper functioning of fine bubble diffusers.

8.18.15.7 Chemical Considerations

Provision to dose Alum (For P removal) shall be considered based on Inlet Parameters. Provision to dose External carbon to be considered if BOD: TKN ratio is to be less than 4.

MBBR Treatment Technology

GENERAL

The Moving Bed Bio Reactor (MBBR) process allows carrier elements to move about freely within an aerobic reactor. Sieve assemblies shall be used to retain the carrier elements within each reactor. Wastewater is fed to the MBBR reactor on a continuous basis. A portion of settled sludge becomes WAS while the remaining sludge is pumped back to the Anaerobic zone of the plant as RAS.

Biofilm Carrier Elements

Material is an extruded, Virgin high-density polyethylene. The density of the biomedia shall be nominal of 0.98 and a minimum of 0.96. Minimum effective surface area for biofilm carrier elements in bulk for biomass growth is 500 m^2/m^3. The media needs to be of an extruded type and not injection molded. The biofilm carrier elements shall have a maximum diameter of 20 mm with a Nominal height of 5 to 10 mm. The system supplier shall provide carrier elements.

Aeration System for media

The entire aeration system shall be a full floor coverage device. Each aeration grid shall comprise of central manifold of 316 SS Schedule 10 thickness equipped with diffuser laterals of 316 SS (seamless) Schedule 10 thickness. The laterals shall be mounted on both sides of the center manifold, equally spaced along the length of the manifold. The laterals will have 4 mm holes drilled at equally spaced intervals. The aeration manifold shall be designed to provide uniform distribution of air to each lateral and allow for a turn down of 50% of the design airflow without loss of equal distribution of air to each lateral.

Sieve Assemblies

A total of one (1) sieve assembly shall be provided in the reactor. Individual sieves shall be constructed of stainless steel 316 perforated plate and have a minimum of 55% open area. The openings within the sieve assemblies shall be a minimum of 12 mm diameter and provide a minimum of 30 m2 area per basin for maintaining a maximum headloss of 5 cm through each reactor at peak hydraulic flows of surface. Sieves shall be stiffened at specific locations as required based on sieve length using solid stainless-steel material. The system supplier shall provide the required sieve assemblies.

Supports

The system supplier shall provide all necessary supports for the aeration manifold and sieve assemblies. All submerged supports and connection hardware shall be constructed of stainless steel, Type 316.

MEDIA, PIPING, AND APPURTENANCES

Components of the moving bed biofilm reactor treatment system shall be fabricated of the following:

Biomedia	Virgin HDPE – Extruded
Media Shape	Cylindrical with internal fins/spokes
Aeration Grid	Stainless Steel, Type 316
Sieve Assembly	Stainless Steel, Type 316
Supports	Stainless Steel, Type 316
Bolts, Nuts & Fasteners	Stainless Steel, Grade 316
Washers, Flat	Stainless Steel, Grade 316

All fasteners and anchor bolts shall be 316 stainless steel unless otherwise indicated. Anchor bolts shall be provided for mounting the aeration system and sieve assemblies.

~~The contractor should provide detailed bioreactor calculation including but not limited to bioreactor volume, media volume, basis for adopting nitrification rate on moving carrier media and on MLSS, air requirement, and nitrate and sludge recycle rate.~~

Ultra Filtration System (Submerged/ Pressurized)

Ultrafiltration system is provided after the disc filtration system unit, and bidder can propose either Submerged or Pressurized ultrafiltration system based on the suitability of site and considering ease of operation and maintenance of the Ultrafiltration units. The ultrafiltration Plant output shall be minimum 50% of WwTP Plant capacity (20 Hours of Operation) and all the process units and equipments shall be designed to match the output capacity of the plant. For Particular requirements, refer in Volume 2, Section 7 Part 5 of the bid document.

The Ultrafiltration treatment for **Each battery/ module Skid arrangement** shall include but not limited to the following items listed below.

a) Ultrafiltration module with rack suitable for Pressurized membrane **or** Ultrafiltration modules for Submerged membrane with housing with complete inlet and outlet Piping, Valves etc. arrangement.

b) Ultrafiltration system shall have Positive Displacement Rotary Lobe Blower of suitable capacity of minimum 2 Nos. (1W+1S).

c) Ultrafiltration Feed Pumping arrangement with VFD operation of suitable capacity of minimum 2 Nos. (1W+1S) either Submersible or Horizontal centrifugal Pump sets.

d) SS 316 Basket Strainer or Pre filters before feeding it to the UF membranes. The Contractor shall provide Self Cleaning strainers to remove particles and debris, such as drill shavings, present in the secondary effluent that could be expected to damage the membranes used in the UF process. The screening properties of the strainer shall be based on the requirements of the UF membrane process. The self-cleaning filters shall be automatic with a self-cleaning backwash mechanism.

e) Permeate Transfer Pumps or Filtrate transfer with VFD operation with Pumping arrangement of suitable capacity of minimum 2 Nos. (1W+1S) Horizontal centrifugal Pump sets.

f) Backwash Transfer Pumping arrangement of suitable capacity of minimum 2 Nos. (1W+1S) either Submersible or Horizontal centrifugal Pump sets.

g) Neutralization Pumping arrangement of suitable capacity of minimum 2 Nos. (1W+1S) either Submersible or Horizontal centrifugal Pump sets.

h) CIP Clear water Transfer Pumping arrangement of suitable capacity of minimum 2 Nos. (1W+1S) Horizontal centrifugal Pump sets. The contractor shall maintain CIP Tank with online level measuring sensor for continuous measurement and control through PLC and HMI.

i) Common units for all battery/ module Skid arrangement such as Sodium Hypochlorite dosing system, Citric acid, Hydrochloric Acid, Sulphuric Acid and any other acid shall be as per process requirement suggested by the vendor. Each dosing unit shall have minimum 3 nos. (2W+1S) chemical dosing/metering pump sets, Dosing Tank of minimum 2 Nos. (1W+1S) if any agitators required bidder shall be included in the design.

j) Air compressor system with Rotary screw or Reciprocating type of minimum 2 Nos. (1W+1S) along with Piping arrangement.

k) Piping: All the liquid piping shall be SS 316 material, Process Air shall be SS 304 material and chemicals usage shall be CPVC only.

l) All the Valves shall be provided based the Process liquid which will be handled and as specified in the bid document only.

m) Properly sized Drain Trenches shall be provided in the Ultrafiltration Building for routing out any leakage from the building.

n) All the Electrical equipment such as MCC Panels and Instrumentation control panels with all necessary interlocks shall be provided for auto operation of the UF Plant. MCC Panel and control Panel shall be of IP 55 Protection.

Ventilation/ Cooling arrangement shall be provided in Control Room with Split Case AC units suitable for total Heat dissipation from the Panels and Occupancy by O&M Personals. All MCC & Control Panels shall be suitable for top entry of cables.

o) The control Panel shall be embedded with the PLC and Panel mounted HMI Touch Screen (10 inch size) and also PLC data shall be interfaced with Plant Main PLC/ SCADA system by using Hard wired communication for continuous monitoring and control from main PLC/ SCADA. Please refer system Architecture drawing of Volume 4 for system integration purpose.

p) The UF Plant shall have safety features like Emergency shut down and fail-safe mechanism in abnormal condition such as Power failure mode, Overflow or Underflow condition at Ultra Filtration feed before membrane skid with cut off operation (As safety interlock), Membrane integrity Breach condition and High chlorine dosing condition with sensor indicating alarms.

q) Noise Level within building shall be limited to 85 dBA with all the units/Equipments in working condition (Such as Blower, Feed Pump, Backwash Pump and Dosing system).

r) The instruments such as rota meters for feed, reject and permeate and pressure indicators for feed, reject and permeate shall be located on the SUF skid such that all instrument have easy access and good visibility.

s) Lifting Arrangement shall be considered based on the heaviest equipment which will be lifted from the UF building.

t) Ventilation with minimum 10 to 12 air changes/hour shall be considered and fire safety equipments shall be provided in the area.

u) Safety Precautions sign board shall be provided based on the acid usage in the UF plant.

v) For submerged membrane tanks, shall be provided with suitable sized Sluice gate at inlet and outlet points.

w) Proper illumination shall be provided for the UF building/Room.

x) All the cable shall be provided with proper closed cable tray and conduits.

y) For Submerged membrane proper inspection platform with Electric hoist arrangement shall be provided for ease of operation and maintenance.

z) Minimum spares shall be maintained at the plant premises to have continuous supply of treated water minimum output of the plant.

A. Minimum Process Performance Monitoring Instruments

The treatment facility shall have the following process performance monitoring instrumentation as
a minimum:

- Additional instruments for refurbished WwTP's for continuous online monitoring – Raw
- Sewage: Flow, Pressure, Turbidity, Temperature, TOC, pH, Conductivity Treated.
- Secondary Sewage: Flow, Turbidity, Temperature, TOC, Residual Chlorine, Conductivity,
- pH Value.
- Secondary Treated Sewage Transfer: Flow, Pressure, Residual Chlorine.
- UF Feed Common header: Turbidity, Temperature, TOC, Residual Chlorine, Conductivity,
- Free Oil.
- Individual UF Train Feed: Pressure, Flow.
- Individual UF Train Permeate: Turbidity, Pressure, membra ne flux (calculated), TMP.

(calculated)

- Backwash Inlet: Pressure, Flow.
- CIP Inlet: pH, Pressure, Flow.
- UF Air Blower: Flow, Pressure.
- Self-Cleaning Filter: Differential Pressure
- All Storage Tanks: Level with redundancy
- All dosing Tanks: Level
- All pump discharge: Pressure
- UF Reject Transfer: Pressure, Flow
- Chemical Unloading pump: Pressure, Flow

- Neutralized Chemicals: pH, Chlorine, Pressure, Flow
- Tertiary Treated Sewage Transfer: Flow, Pressure, Turbidity. Residual Chlorine
- Compressed Air: Pressure, Dew
- Utility and Potable Water: Pressure, Flow

The type of instruments for TTP shall be as indicated in the P&ID and in the instrumentation section. The Contractor shall maintain the failsafe mechanism with redundancy features of field instruments for critical parameters like TMP, Flow, pH and residual chlorine at inlet and Outlet.

B. Chemical Storage and Dosing for TTP

The Contractor shall equip the Plant with centralized chemical storage area(s). The capacity of each chemical should have a volume which is equivalent to 14 days of full load operation for bulk storage tanks and 7 days for small dosing tanks. The chemical storage area shall be either indoor or sheltered with a roof. The chemical storage tanks shall be bunded (each chemical separately) to ensure that an accidental leakage is retained within the bund. The bund shall be of sufficient volume to contain 110% of the entire contents of the contained tanks.

C. Submerged Ultrafiltration (SUF)

General

- Ultrafiltration (SUF) with submerged membrane modules can be used for various water purification applications.
  - Tertiary effluent treatment in wastewater treatment plants (WwTP).
- The material for membranes used shall be Braided / reinforced PVDF. The module size, its pore size, operating and back flush flux rate, temperature stability, solvent resistance, bacteria inhibition and resistance to fouling of the membrane shall be suitable to cater to the required duty.
- Adequate space shall be provided on the feed and reject side of the SUF skid to ensure easy loading and unloading of the SUF membranes.
- All the components of the chemical cleaning system shall be able to withstand extreme pH and temperatures up to 45°C.

D. Working Principle of Submerged UF Process:

- Within a SUF process the submerged membrane modules are typically installed in one or more separate membrane tank(s) downstream of the former process steps. Mechanical pretreatment is required to remove fibrous material, large particles and other materials that may be harmful to the membrane from the SUF system. The required type of pretreatment depends on the kind of the water source upfront.

- After mechanical pretreatment, the wastewater is fed to the membrane tanks where the water is separated from the solids by the SUF membranes. The liquid is typically fed below the submerged membrane modules.

- The filtered water (or permeate) passes through the membranes by means of a permeate pump which applies a vacuum on the interior of the membrane fiber. The concentrate is retained in the membrane tank. In case of tertiary effluent filtration, it is typically recycled back upfront of the biological process to remove the solids with the surplus sludge. In case of surface water treatment, the concentrate is typically returned to the water body (depending on local rules and regulations).

- The filtration tanks (also called trains or filtration lines) are typically designed with some degree of redundancy to allow the system to operate and treat the required liquid flow rate when part of the membrane area is down for cleaning or maintenance.

E. Operating Modes for Submerged Membranes in a UF System

- For a hollow fiber membrane configuration, the membrane portion of the SUF system has two basic operating modes: production and chemical cleaning. During production mode, feed water flows from the upstream treatment steps to the membrane tanks. Depending on the application, concentrate may be removed from the membrane tank either continuously (feed & bleed process) or dumped in regular intervals (dead-end or batch mode).

- Depending on the system layout, the UF filtration system may be designed with pumped feed, or gravity feed. As water is pulled through the membranes as

permeate, solids accumulate on the surface of the fiber bundles causing an increase in differential pressure across the membrane surface. Several flux maintenance techniques are used in a submerged hollow fiber membrane configuration.

F. Air Scour

- Mechanical removal of solids from the membrane surface is accomplished through the use of air scour which is applied to scrub the outside surface of the membrane and removal with the concentrate.

G. Permeate Backwash/Flush

- With Permeate Backwash/Flush, the permeate flow is reversed through the membranes is used to control the solids concentration at the membrane surface to help maintain membrane filtration system performance and increase the time between membrane cleaning cycles.

H. Chemical Cleaning

- Over time however, materials will adhere onto the surface of the membrane which cannot be removed by a mechanical means (i.e. backflush or air scour). Accumulated substances, such as biofilm, scale, or other deposits on the membrane surface, require a chemical cleaning. Cleaning is discussed in greater detail in the next section.

- Permeate pumps are used to extract the treated water through the membrane. The same permeate extraction system is also designed to push permeate back into the membranes during backflush cycle. The two most common permeate extraction systems are based on a reversible pump and on a centrifugal pump.

- Common chemicals such as sodium hypochlorite, citric acid and any other mineral acid are used to chemically clean the membranes.

- The type of chemicals used depends on the nature of the foulant and the membrane materials of construction. There are two types of chemicals cleans utilized in system - Maintenance Clean (MC) and Recovery Clean (RC). MCs are shorter, regularly scheduled and are employed to maintain the membrane permeability.

- For MCs and RCs, the tanks are drained and re-filled with cleaner chemicals solution. MCs are realized with lower chemical concentrations and lower contact time. RCs are more intensive cleans that are used to restore the membrane permeability. RCs are typically performed typically once per 1 - 2 months and additionally when the system experiences upset conditions.

- Maintenance clean is normally fully automated while RC may be semi-automatic.

- Two or three chemical dosing systems are typically incorporated in the design of the filtration section of the SUF system, to deliver sodium hypochlorite and citric acid / mineral acid for the in-situ membrane cleaning cycles.

- The SUF product is a supported hollow fiber membrane operating with an outside-in flow path. The solids remain on the outside of the fiber and the clean permeate passes through the membrane and collects in the internal bore of the fiber. Vacuum is applied to the inside of the fiber to pull the clean water through the membrane wall.

- The SUF membrane is a hollow fiber membrane cast on a braided support and has been specifically designed to address the aggressive nature of the wastewater treatment environment in which it operates. The braided support results in a high mechanical strength composite membrane, making it virtually impossible for individual fibers to tear, break or delaminate during normal operation.

- The consumption of cleaning chemicals strongly depends on the specific parameters of each plant and on the operational conditions. It will also depend on the hardness and alkalinity of the water source, which will determine the required schedule of acid MC and RC. Membrane cleaning procedures are typically optimized during the first year of operation of the plant.

- Comprised of a Braided / Reinforced PVDF formulation, the distinctive morphology of the membrane provides superior performance. With high porosity and a nominal pore size of 0.03 micron, the membrane resists fouling while providing high sustainable flux rates. As a result, it responds better to cleaning regimens yielding higher permeability recoveries, lower trans-membrane pressures (TMP) during filtration, and extended life potential. A summary of

membrane properties and common operating parameters appears as per below table.

Technical Particular	**Parameters**
Membrane technology	Ultrafiltration (SUF)
Membrane Type	Braided or Reinforced Hollow Fiber
Braid / reinforced material	Polyester or if any as per vendor recommendation
Feed Temperature	20 to 38 degree C
Membrane material	PVDF
Nominal pore size	0.03 microns (maximum)
Driving force	Vacuum
Permeate flow direction	Out to-In
Nominal fiber Diameter (OD)	1.2 to 2.6 mm
pH Operating range	2.0 – 10.5
Operating temperature range	41 - 104 °F / 5 - 40 °C
Maximum backflush transmembrane pressure	9.0 psi / 0.6 bar
Maximum filtration transmembrane pressure	9.0 psi / 0.6 bar
Fiber Strength	> 600 N
Minimum Operating life for Membrane	10 years
Specific Energy Consumption kWh/m3 (Treated)	Vendor to Provide details
Individual Modules are accessible for any replacement/future modules additions	Vendor to Provide details, If Yes, provide details of provisions for Spare modules.

I. Single Header Design

- Some SUF membrane modules have difficulty dealing with fibrous material, which tends to clog vulnerable areas in the module leading to operating and maintenance problems. The clogging problem is common and noticeable in double header hollow fiber products at the top header, where hair and fibers that passed through the system pretreatment are forced into the potted membrane bundle by the aeration system.

- Sludging at the bottom header often occurs in some products because there is little or no air scour to remove sludge from the base potting area. In addition, membranes that are potted at both ends or held around the edges often require over sizing to allow for expansion, contraction and to prevent breakage during manufacturing. This practice causes strain under normal operating conditions particularly during aeration, which often results in membrane integrity failure and delamination.

- The SUF product consists of bundles of hollow fiber membranes potted only at the lower end of each bundle. The non-potted ends of the fibers (at the top of the bundle) are individually sealed and move freely in the liquid. The lower end of the upright membrane bundle is fixed in a foot element, with a central air nozzle to inject air into the center of the membrane bundle, the place with the greatest potential for solid accumulation.

- Single header product with central aeration provides agitation from the bottom of the membrane bundle and free-floating fiber tips, allowing the fibrous materials to float free of the module.
  In this configuration provides the following advantages:
  - Reduces clogging and sludging.
  - Allows higher fluxes.
  - Allows for intermittent aeration and lower aeration rates.

J. Central Aeration System

- The central aeration system allows maximum utilization of the air that is delivered into the center of each membrane bundle. This configuration forces the air to expand the bundle and move from the inside to the outside of the membrane fibers.

- This design exposes the entire fiber length to air scouring with the air applied directly to the area of the membrane that is most susceptible to solids accumulation (i.e. the center of the bundle). Other membrane systems, where the air is applied around or below the membrane permeate header, cannot offer this level of efficiency.

- The sheer force of the injected air scours the entire length of the membrane surface removing deposits from the membrane. Fibrous substances do not

clog the top of the bundle since it is not potted, and the potentially harmful material is allowed to pass freely through this area. Module sludging and clogging is largely prevented with the central air scour nozzle and free-floating membrane tip design utilized by module.

K. PVDF Membrane with Braided

- The membrane fiber features a Braided PVDF membrane formulation cast on polyester support braid. The PVDF membrane exhibits a tight pore size distribution with a nominal pore size of 0.03 micron. This membrane formulation permits the membrane to operate at high flux rates with low fouling characteristics. In addition, the support braid is virtually unbreakable, leading to a robust product with a long serviceable membrane life.

- The fiber is braided, allowing it to go through intensive backwash cycles that are critical to maintain high flux rates and overcome sludging events. These backflush cycles, combined with the single header configuration and central aeration, allow the product to maintain high peak flux rates in high solids SUF applications up to 2000 mg/l in the tank.

- The module terminology indicates the single header design and the membrane area for a fully installed module.

- The centrally aerated membrane bundles form the basis of the module. The fiber supports prevent the membrane fibers from bending, particularly during installation or removal of the module.

- The integrated header on the bottom of each row contains two separate chambers - one for air distribution and the other for permeate extraction and backflush. The permeate chamber is attached to a lift pipe that directs the filtrate upwards where it is led into a center collection header. A similar arrangement is used for the air distribution.

- The individual membrane rows, two permeate collection headers and the two air distribution headers, are mounted on a self-supporting module frame. The membrane module is fitted with lateral permeate connections and two air distribution pipes. Furthermore, plates are mounted on the outside of the

module that serve to significantly reduce clogging and enhance the flow pattern through the module.

L. Aeration Requirements

- The membranes operate either with a cyclical air scour delivery, requiring aeration only during a low percentage of the time or only during the backwash sequence. This depends on the water source, the type of solids to be removed and the concentration of these solids.

- This aeration regime allows the membrane to offer one of the lowest air scour requirements in the industry as many other membrane systems require higher air scour delivery rates while operating in similar applications.

Technical Particular	**Parameters**	
Length of Membrane Module	mm	As per Vendor Recommendation
Width of Membrane Module	mm	As per Vendor Recommendation
Height of Membrane Module	mm	As per Vendor Recommendation
Dry Weight of Membrane Module	Kg	As per Vendor Recommendation
Maximum No. of Membrane Rows which can be installed per Module	No.	As per Vendor Recommendation
Filtration Area of each Row	m2	As per Vendor Recommendation
Filtration Area of Module	m2	As per Vendor Recommendation
Membrane Fiber Chemistry		PVDF (Braided Fiber or Hollow Fiber (Reinforced)
Fiber Support Chemistry		Polyester or if any other as per Vendor Recommendation
Membrane Module Assembly		Single Header

Technical Particular	Parameters	
Membrane Module Frame or Rack Material		SS 316
Spare space for module per Train		10%
Nominal fiber Diameter (OD)	mm	1.2 to 2.6 mm
Flow Direction		Out to– In
Nominal Pore Size	micron	0.03 microns (maximum)
Feed Temperature		20 to 38 degree C
Housing Material and Permeate Collection Tube Material		UPVC ABS, PVC, PE Manifold
Permeate Connection Type		Grooved Coupling of suitable size
Air Connection Type		Grooved Coupling of suitable size
Maximum Filtration Transmembrane Pressure	Bar	0.6
Maximum Back Wash/ flush Transmembrane Pressure	Bar	0.6
Acceptable Range of Cleaning pH values		2.0 – 10.5
Lifetime Total Chlorine Exposure	ppm-hrs.	5,00,000
Maximum chlorine Concentration	mg/l	1,000 (as NaOCl)[3]
Minimum Operating life for Membrane	Years	10
Specific Energy Consumption	kWh/m3 (Treated)	Vendor to Provide details
Individual Modules are accessible for any replacement/future modules additions	Yes/No	Vendor to Provide details, If Yes, provide details of provisions for Spare modules.

8.19 ~~Scum removal equipment- Common for all type Technologies~~

~~In the biological reactors, scum may be generated due to the BOD SS quality of the influent sewerage.~~

The occurrence of scum indicates the status of sewage treatment maintenance and management and may lead to deterioration of the quality of discharged sewage water.

If scum is caused by actinomycetes, suspended solids, denitrification gas, etc., remove it with a scum skimmer and send it directly to the sludge treatment process so that it does not adversely affect the biological reaction tank.

The removal of scum is achieved by lowering the depth of the scum recovery opening part (drainage section) below the surface level of the sewage surface, allowing the scum and sewage to efficiently flow into the drainage trough / drainage pipe due to the difference in water level, and collecting the scum in the scum pit under gravity flow.

In addition, since the scum pit is installed near the water surface, it is affected by the mixed wave caused by the agitation of the sewage and Power of buoyancy.

The following points shall be noted when constructing the scum skimmers.

- The scum skimmer has sufficient strength and is fixed to the wall.
- The material selected shall be highly corrosive.
- The scum recovery opening part shall be installed at the same level as the water surface.
- The scum generated on the back of the scum skimmer can be removed.
- When the scum skimmer is not operated, the scum recovery opening part shall not be affected by the mixed wave and high water level.
- When the scum skimmer is under operation, the water level of scum recover opening part should be lowered to a maximum depth of 100mm.
- The operation of the scum skimmer should be performed manually while checking the scum occurrence.
- The removed scum and sewage will be drained smoothly.
- The bearing part / bushing shall have a structure that allows easy operation of the scum skimmer, easy installation accuracy work, corrosion resistance, and does not cause operation failure due to adhesion of the scum.

8.19Primary/Secondary Clarifiers

Circular (radial), fixed bridge with scum collector, Central turns drive type, collecting effectively with proper circumferential speed, clarifiers shall be provided. The clarifier shall be rugged and robust in design and shall be provided with high capacity drive head and induction motor having high torque rating,

centrally located, with positive sludge raking by means of one or more raking arms. Both the raking arms should have scraper blades fitted at the bottom, so that the sludge from scraper blades is pushed to the sump on every rotation.

(a) The drive head mechanism arrangements shall consist of a turn table base casing mounted on top of the centre pier and shall have an angular ball bearing mounted internal gear that supports the underwater mechanism. The pinion meshing with the internal gear should be driven through a worm gear reduction unit mounted on top of the turn table drive unit. The balls should ride on hardened steel strips set into grooves in the base and gear casing so that they can be readily replaced whenever required.

(b) The unit will have mechanical overload arrangement with a torque indicating arrangement along with necessary contacts for tripping the motor in the event of overloading. This condition shall be annunciated. The unit shall have push button station near the motor and starter with push button shall be provided in the control room, i.e. the return activated sludge pump house along with necessary switches. The clarifier unit should also be provided with necessary M.S. scum trough, scum baffles, skimmer assembly, M.S. rake blades, arms and brass squeezes. The V-notch weirs shall be 6 mm thick of SS 304 with SS 316 clamps & fasteners etc. for making the necessary adjustments.

(c) Scrapers supplied by the Contractor shall generally be manufactured in protected mild steel, in accordance with the requirements of the Specification and especially where Mild steel is proposed for underwater structure, the part shall be coated with polyurethane for a minimum 180 to 250 microns.

(d) Material such as stainless steel (SS316) shall be provided for specific items as sludge scraper blades. Where mild steel is proposed, the protection system shall give a typical life to first maintenance of at least 15 years.

(e) The bridge connecting the periphery of the tank to centre pier shall have walkway covered with chequered plates and provided with hand railing on both sides.

(f) The Clarifiers shall have a bridge complete with 1200 mm walkway for personnel access to the centre, access stairs to ground level and hand railing, a motor driven sludge scraper complete with all necessary controls, delivery pipe work, a stilling well and overflow steel weir plates. Hand railing, MS Chequered plate walkways of minimum 6 mm thick,

access steps etc. shall be galvanized. Handrails shall be of tubular construction and made of 50 NB pipes heavy duty class.

(g) The scrapers shall be fitted with rotation monitors and over torque protection to alarm in the event of a failure.

1) Corrosion allowance of 2 mm shall be taken in the structural sections of scraper arm, bridge etc.
2) Structural design calculations shall be submitted for all structures including scraper arm, bridge etc. and also the calculation for drive head selection including the Torque Rating.

(h) Scum collected by the scum skimmer is effectively collected in a scum box, and it is mix with excuses sludge pump and dehydrated.

(i) Clarifier sludge draw-off pipe shall be provided with a Manual & Motorized Knife Gate valve and flowmeter measurement.

8.20.1 Rectangular Sedimentation Tank

General

Rectangular Clarifier or Sedimentation tanks shall have a length to width of not less than 4:1. It can be installed in Single/Two/Three Deck system. The sludge collector shall be a chain flight type and be installed for the purpose of scraping the settled sludge into the hopper provided by the side of the tank.

Each tank shall have wastewater delivery in the form of an inlet channel spanning the entire width of the tank and multiple submerged ports for low turbulence inlet feed into the tank.

The sludge collector shall be constructed with endless chains having flights mounted at definite intervals. The endless chain shall be driven through sprockets on the drive shaft and idle shaft to move the flights along the rail surfaces on the tank bottom so that the sludge may be scraped into the sludge hopper.

In this construction, the scum generated on the water surface in the clarifier is scraped from the return side of the sludge collector so that it may flow into the scum skimmer.

The scum removal equipment at the effluent end of the tank shall consist of a rotatable pipe trough with a longitudinal slot running of the pipe. The pipe shall span the width of the pass/tank and discharge into a scum accumulation chamber. The scum trough shall be rotated via the use of a handwheel actuated gearing with extended spindle.

~~For extremely long sedimentation passes/tank, the maximum length of the chain and flight system for each pass shall not exceed 60 m.~~

~~Design Conditions~~

~~(1) Collector chain~~

~~(a) Type: Engineering Plastic or SS 316 L~~

~~(b) Pitch: About 150 to 200 mm~~

~~(c) Rupture strength: Guaranteed minimum: 15 kN~~

~~: Average: 20 kN~~

~~(2) Sprockets~~

~~(a) Pitch: About 150 to 200 mm~~

~~(3) Scraping speed~~

~~(a) Primary clarifier: About 0.6 to 0.8 m/min~~

~~(b) Secondary clarifier: About 0.3 to 0.7 m/min~~

~~(4) Collector flight mounting pitch: About 3 m~~

~~Fabrication~~

~~(1) Drive unit~~

~~The drive unit shall be a horizontal cycloidal reduction gear or planetary reduction gear. Power shall be transmitted by chain transmission system and the speed shall be reduced to the predetermined sludge scraping speed. The transmission chain shall be arranged on the sprockets with the return side up, as a rule.~~

~~The drive chain which will be submerged in water shall be a stainless steel SS 316L.bushed chain. Or, a chain tightener shall be provided, as necessary.~~

~~(2) Collector chain~~

~~The chain shall be made of Engineering Plastic or SS 316L chain with high wear resistance and corrosion resistance. It shall be constructed easy to disassemble and adjustable in chain elongation.~~

~~(3) Sprockets~~

~~(a) For the sprockets for the drive chain, a special pin type wheel (if any), shall be used considering wear.~~

(b) For the sprockets for the collector chain, a special pin type wheel (if any), shall be used for the drive shaft considering abrasion, and a Engineering Plastic or SS 316L sheave type wheel for the idle shaft.

(4) Collector flights

(a) Collector flight material shall be of fiber reinforced plastic, FRP.

(b) For each tank, rubber plates to scrape the sludge to the tank bottom surface shall be mounted at ends of two collector flights.

(c) Regarding wear shoes, adequate consideration shall be given to their mounting intervals, etc. and an adequate allowance for wear shall be provided, so that the collector flights may not contact the concrete wall, bearing stand, rail holder, etc. and the collector flight strength may not be damaged.

Accessories shall be supplied along with steel plate common base, Drive unit and chain cover, Mounting bolt and nut Anchor bolt and nut.
Chain and flight mechanism shall have material of construction as below:

(1) Collector chain

(a) Chain main body: Engineering Plastic or SS 316L

(b) Pin: Engineering Plastic or SS 316L

(2) Shaft

(a) Drive shaft: Stainless steel SS 316L

(b) Idle shaft: Engineering Plastic or SS 316L

(3) Bearing

(a) Drive shaft bearing: Engineering Plastic or SS 316L

(4) Sprockets

(a) For collector chain for idle shaft: Engineering Plastic or SS 316L

(5) Collector flights: Fiber reinforced plastic (FRP)

(6) Guide rails: Stainless steel SS 316L

(7) Bottom rails: Engineering Plastic or stainless steel SS 316L

(8) Guide rail bracket: Stainless steel SS 316L

(9) Wear shoes: Engineering Plastic or stainless steel SS 316L

(10) Anchor bolt and nut: Stainless steel SS 316L.

Protection Equipment

(1) Electrical protection equipment: Electrical components shall conform to relevant local or IEC standards.

- Overcurrent detector/relays for overload protection (electrical works)
- Short circuit protection

(2) Mechanical protection equipment

Speed reducer built in torque limiter for overload protection

8.19Gravity Thickeners

Circular (radial), fixed bridge, central turn table type or peripheral drive type picket fence, collecting effectively with proper circumferential speed, a clarifier shall be provided. The Thickener shall be rugged and robust in design and shall be provided with high capacity drive head and induction motor having high torque rating, centrally or peripherally located, with positive sludge raking by means of one or more raking arms. Both the raking arms should have scraper blades fitted at the bottom, so that the sludge from scraper blades is pushed to the sump on every rotation. It is fundamental to treat sludge with a sufficient cohesive effect.

When the excess sludge with insufficient coagulation effect is concentrated by gravity, if the concentration time is long, phosphorous is released from the aerobic sludge, and the phosphorous concentration of the supernatant water may increase. Therefore, the mixed sludge treatment of the scum generated from the excess sludge, the biological reaction tank, and the final sedimentation basin needs to be processed promptly. Scum generated in the thickener is removed by a scum skimmer and processed appropriately.

(a) The circular reinforced concrete thickeners tapering at bottom shall be provided for thickening process.

(b) Design shall be such that the sludge can become compacted and can be extracted from the bottom. Interstitial liquid flows through peripheral weir at top. Tanks shall be deep enough to allow the sludge to settle. At least 50 cm freeboard shall be provided. Provision shall be made to remove the sludge from top if there is a serious risk.

(c) Provision shall be made for collection of thickened sludge and pumping it to Centrifuge.
A full diameter bridge with walkway with central drive shall be provided with: central platform for the installation of the scrapers and their drives and for the local control panel; a radial scraper system with bottom scraper blades, suspended on the bridge.

(d) The thickeners shall have a full diameter fixed bridge complete with 1200 mm walkway for personnel access to the center, access stairs to ground level and hand railing, a motor driven sludge scraper complete with all necessary controls, delivery pipe work, a stilling well and overflow steel weir plates. Hand railing, MS Chequered plate walkways of minimum 6 mm thick, access steps etc. shall be galvanized. Handrails shall be of tubular construction and made of 50 NB pipes heavy duty class.

(e) The scraping gear shall be supported from the tank base and from a fixed bridge carrying the central electrical drive for the rotating gear. The equipment including driving motor, gears, shafting and scrapers shall be designed for continuous operation and sized for the most arduous operating condition including starting from rest with an accumulation of sludge in the thickeners.

(f) The electric motor, gearbox etc., shall be provided with a sunshade (Canopy).

(g) The fixed bridge, hand railing, access steps and the feed well shall be galvanized steel. The main drive shall be cast Iron construction and shall be enclosed in a dust proof enclosure with oil bath lubrication. All underwater hardware shall be of SS316.

(h) Suitable overload protection for the drive shall be provided to ensure that the sludge shall not overload the equipment and emergency stop pushbutton shall be provided.

(i) The scrapers shall be fitted with rotation monitors and over torque protection to alarm in the event of a failure.

1) Corrosion allowance of 2 mm shall be taken in the structural sections of scraper arm, bridge etc.
2) Structural design calculations shall be submitted for all structures including scraper arm, bridge etc. and also the calculation for drive head selection including the Torque Rating.

(j) V-notch weir in SS 304 construction of size minimum 6 mm thick and 200 mm wide shall be provided along the launders for uniform draw-off of the overflow. The weir plate shall be fixed to the launder by means SS 316 grade clamping plates and fasteners.

The hydraulic equipment will consist of the DI inlet pipe (runs along the bridge) to the central feed well of the thickener; sludge draw-off pipe with

an manual & Motorized Knife Gate valve (in SS CF8M material of construction) for intermittent operation according to an adjustable timer; a drain pipe with manually operated gate valve for the complete emptying of the unit; a discharge pipe/channel from the peripheral collecting channel to the main channel leading to the Supernatant sump.

(k) The sludge thickener mechanism shall be generally in MS galvanized construction, suitable for installation in a circular RCC tank and shall include the following:

a. Mechanism support beam spanning the diameter of the tank.
b. Walkway and handrail from the edge to the centre of the tank.
c. Drive mechanism with internal gear type.
d. Reduction gear box.
e. Chain and sprocket with guard.
f. Central shaft with scrapper arm and picket fence.
g. Skimmer Scum Baffle and Scum trough.
h. Overflow weir.
i. Vertical pickets.
j. Torque Indicating Device.
k. Overload Alarm protection.
l. Auto lifting device with minimum 300 mm lift.

8.19 Dewatering Centrifuges

(a) The Dewatering Machine and its peripheral equipment shall include but not necessarily be limited to the following;

(1) Powder or liquid Coagulant storage tanks.
(2) Mixers and solution tanks.
(3) Coagulant service tanks.
(4) Supply line & flush line.
(5) Chemical feeding pumps.
(6) Water supply pumps.
(7) Sludge feeding pumps.
(8) Dewatering Centrifuge
(9) Screw conveyor.
(10) Cake hopper.
(11) Flow meters for feeding Sludge, and for feeding chemical solution.
(12) Control valves on sludge feeding line, and on Chemical feeding line.
(13) Drain system.

(b) Dewatered cake shall be conveyed by a screw conveyor to cake hopper for carrying out for reuse. The performance of the centrifuge shall be taken into account the conditions necessary for dumping the dewatered cake to the waste disposal site by a truck.

(c) To select the type of dewatering machine, Contractor shall provide technical information to show client that performance to obtain his approval in advance.

(i) Decanter Centrifuge

The centrifuge shall comprise a conical cylindrical bowl and scroll feed horizontally mounted in bearings on a frame. The centrifuge bowl and scroll support frame shall be mounted on a fabricated steel sub-frame.

The bowl and scroll shall be made from stainless steel AISI 316 material. The leading faces of the scroll shall be protected against abrasive wear by the application of a suitable hard coated material (Tungsten carbide).

The whole rotating assembly shall be enclosed by a Stainless steel (AISI 316) fabricated casing incorporating a Centrate discharge hopper and outlet pipe, and a rectangular solids hopper which shall discharge the dewatered sludge into the disposal system.

The rotor shall consist of a solid bowl which is conical-cylindrical in shape and which rotates about a central shaft. An inner scroll shall be provided to convey separated sludge from the periphery of the cylindrical bowl to the beach at the conical end of the rotor.

The main scroll bearings shall be arranged for lubrication by an external lubrication system. Wherever practicable greasing nipples shall be arranged together as a battery. The complete rotating assembly shall be dynamically balanced and test certificates provided.

Sludge shall be fed into one end of the rotor through a centrally positioned feed tube and dispersed to the bowl through an inlet chamber.

The bowl shall be provided with an adjustable 360° peripheral weir at its cylindrical end to control the depth of the Centrate in the rotor.

The fixed outlet castings of the rotor shall be designed to collect the centrate and dewatered sludge from the rotor. Baffles within the casing shall direct the separate phases to the relevant discharge points and prevent cross-contamination.

The centrifuge shall be mounted on heavy duty vibration isolators, located between the machine and the supporting steelwork or foundations, to damp

vibrations and prevent vibration transmission. Two axis vibration monitors shall be provided to stop the centrifuge automatically when excessive vibration is detected.

Flexible connections shall be provided on the sludge fed system and the Centrate system in the centrifuge. The dewatered sludge discharge system shall incorporate flexible chutes.

(ii) Variable Speed Drive

A variable speed drive shall be provided to accelerate the rotor to operational speed and maintain that speed during the centrifuge's duty period. The bowl drive shall be electric or hydraulic and shall be coupled to the drive shaft by a multiple 'V' notch belt drive.

(iii) Differential Scroll Drive

The scroll drive shall be provided with a separate drive mechanism to control its rotation in the same direction but at a different speed to the outer bowl. The differential speed shall be adjustable. The Centrifuge shall have both front drive and Back drive mechanism.

The drive shall be linked to the main bowl drive by an epicyclic gearbox. The differential speed of the scroll shall be automatically and manually adjustable so that the moisture content of the dewatered sludge can be controlled as required.

For safe operation, contractor shall provide control panel showing proper Sequence of operation with interlocking.

Chutes and interconnecting piping shall be provided with flexible joint (minimum 10 mm flexible in all direction) to avoid vibration.

8.19Conveyor System

(a) For the disposal of sludge a common motor driven endless belt conveyor shall be provided. The conveyor shall be designed in accordance with IS 11592 or equivalent. The conveyor and chutes shall be suitable for handling occasional heavy objects which will cause shock loads.

(b) The construction of the frame and support shall be robust and torque resistant. Belt conveyor shall be of 20 deg. Trough type complete with drive assembly structures, idlers, pulleys and belt cleaners. Idlers and pulley shall be provided with anti friction bearings.

(c) The belt material shall be two ply nylon or equivalent with minimum 3 mm neoprene covering on carrying side. Splicing shall be employed to make the belt endless. The belt shall operate over three roll twenty degree,

troughing idlers. The idlers shall rotate on precision type, deep groove, single row ball bearing with built in close fitting triple labyrinth grease seal. The ends of the outer shell shall be counter bored and a full length centre tube journalled concentricity. The outer shell, centre tube and precision die formed steel ends shall be brazed into an integral unit to provide concentricity. The ends of the centre tube shall be bored concentrically with each other after roll assembly to provide correct bearing alignment and to provide prestressing of boring. The centre tube shall be grease fit after assembly. Troughing idlers shall have means of adjustment or ensuring belt tracking. On the return run the belt shall operate over flat roll idlers having bearing, shaft and lubrication arrangements as above for carrying idlers. Spacing of idlers shall be of 1200 mm on carrying run and 2400 mm on return run.

(d) The head and tail pulleys shall be manufactured from welded steel/any alloy steel and shall be provided with rubber lagging. Lagging for drive pulleys shall have herringbone grooving. Pulleys shall be equipped with taper lock bushings. The tail pulley shall incorporate a screw rake for adjusting belt tension. Head and tail pulleys shall be adequately guarded.

(e) Shafting for pulleys shall be of heat-treated carbon steel. They shall be forged, ground and polished to obtain close diameter tolerances. The head shaft shall be provided with roller bearing pillow blocks.

(f) The belt conveyor shall be driven by a squirrel cage, TEFC motor. A V-belt drive arrangement shall be provided between the motor and a helical speed reducer, the latter shall be mounted on the end of the head shaft. The driving pulley shaft shall have back stops to prevent backward movement of the belt.

(g) The conveyor shall be supported on appropriate channel sections with 14-gauge steel deck plate between the two runs of the belt and the necessary supports to the floor. The floor supports shall be made out of steel plates having minimum 6 mm thickness. The conveyor shall be protected from weather by a 'dog box' type canopy.

(h) An adjustable belt scraper shall be provided on the hopper end of the conveyor belt. The scraper and attachments shall be of fiber reinforced plastic.

(i) Sludge cake discharge Hoppers shall be provided to transfer the sludge cake from the Centrifuge to the troughed belt conveyor and from the conveyor discharge to skip. The latter chute shall extend beneath the belt scraper and shall allow access for maintenance of the belt scraper. Chutes shall be designed to minimize the accumulation of rags and stringy materials. The sludge cake hopper shall be of MS fabricated with minimum 10 mm thick corrosion resistant painting applied, and it shall be operated by a motorized cut gate for auto operation with load cell

arrangement in the plant. The cake hopper minimum dewatered sludge holding capacity shall be at least for 2 hours.

(j) The conveyor shall be fitted with an emergency stop operated by wire rope at foot level. Two Nos. belt sway switches shall be provided on conveyor.

8.19 Progressive Cavity Pumps

(a) Pumps shall be of the type in which a pumping action is generated by a helical rotating eccentrically within a resilient stator in the form of a double internal helix. The eccentric motion of the rotor shall maintain a constant seal across the stator as it travels through the pump to give a uniform positive displacement.

(b) Pumps shall be arranged generally with a single shaft seal at the suction end. Mechanical seals shall be used. If a flexible shaft is used to accommodate the eccentric motion, a corrosion resistant shroud shall be fitted to prevent fiber build up on the shaft. Enlarged inspection access holes shall be fitted to the suction chambers of all pumps for periodic removal of accumulated debris. The shaft bearing shall be positively isolated from the fluid being pumped.

(c) The rotor material shall be selected for corrosion and abrasion resistance for the fluid being pumped, and for prolonged service life. Hard chrome or other approved coatings shall not be less than 250 micron thickness and shall be diffused into the base material. The rotor shall generally be single stage and shall incorporate not less than 360^{θ} of twist, but for high head applications, it may be necessary to use more than a single stage. The stator shall be of a resilient material selected for chemical and abrasion resistance for the fluid being pumped. Pump speed shall suit the application, where variable delivery output is needed; the pump shall be provided with a variable speed drive. The size and speed range of the pump shall ensure that the highest expected duty point shall lie within the available speed range.

(d) Pumps shall normally be driven by a fixed speed electric motor through reduction gearing and the combined drive shall be continuously rated. Pump and motor shall preferably be mounted in line on a common base plate.

(e) Coupling guards shall be provided, which shall be rigid, securely fixed, and designed so that removal is not necessary during normal operation, routine maintenance and routine inspections.

(f) All motor enclosures shall be provided with ingress protection to IP55. Motor anti condensation heaters shall be provided and shall be suitable for use on a 220V single phase, 50Hz supply. All bearing shall have a L10

design life of not less than 100,000 running hours and shall be designed for loading 20% in excess of calculated maximum loading.

(g) Pumps shall be fitted with individual dry running protection to initiate pump trip. Dry running protection by 'under current' monitoring or 'pipeline intrusive' device shall not be used.

Material of Construction;

S. No.	Component	Material
1	Pump Housing	CI IS210 Grade 260
2	Rotor & Coupling & Connecting Rod	SS AISI 316(HCP) 250 Microns
3	Shaft	SS AISI 410(HCP) 250 Microns
4	Stator	Nitrite black
5	Type of drive	V belt & Pulleys
6	Base plate	MS fabricated
7	Mechanical seals	oil lubricated with tungsten carbide or silicon carbide faces

Pumps models (handling water) shall be selected such that when handling sludge it meets the required duties of the viscous liquid. Pumps shall be selected which gives the required duties close to best efficiency point.

8.19Chlorination System

Chlorine solution diffusers shall be supplied and installed at the dosing point. Treated sewage shall be dosed with chlorine gas at concentrations not more than 10 mg/l. Effluent from the chlorine contact tank shall not have more than 1 mg/l of residual chlorine.

8.25.1 Chlorinators

(a) Vacuum type chlorinators shall be supplied with one duty and one standby unit.

(b) Chlorinators shall be free standing, floor mounted, and shall have a turn down ratio of 10: 1 over the full range of works operation.

(c) Each chlorinator shall be equipped with a motorized plug positioned to be actuated by a sewage flow at the works outlet.

(d) The dosing rate shall be manually set and each chlorinator shall be equipped with a 0 to 10 mg/l scale and a manual dose setter over the complete range.

(e) Mal-operation of the duty chlorination system shall be indicated in the chlorination room and the central MMI. The change to the standby system shall be carried out automatically in the event of a duty chlorinator failure.

(f) Chlorine solution Diffusers shall be supplied and installed at the dosing point.

(g) The plastic sheathed copper tubes connecting the liquid chlorine drums and the liquid chlorine header system shall be equipped with adaptors to accept drums supplied by the Employer.

(h) Flanges and Joints for Liquid Chlorine Pipe Work

Flanges for liquid chlorine pipe work and valves shall be raised face flanged double fillet welded, stress relieved and radiographed, drilled to relevant tables of BS EN 1092-1.

Joint rings shall be 2 mm compressed Asbestos Fibre (CAF) tabbed to BS: 2815 Grade B fitting within the bolt circle. Prior to installation the joint rings shall be impregnated / smeared with graphite compound or similar jointing compound compatible with liquid chlorine.

(i) Liquid Chlorine Pipe Work

Pipe work conveying liquid chlorine shall be carbon steel hot finished seamless, cold drawn seamless to BS: 3602 Class 23 or 27. Pipe work shall be adequately supported throughout its length and sufficient number of flanges shall be incorporated to enable maintenance or repairs to be carried out without having to work from one end of the pipe work.

The pipe work shall include rupture disc and expansion chamber as per recommendations of Chlorine Institute, USA. An alarm switch shall be provided set to function if rupture occurs.

Following any welding work on the pipe work the entire section of the affected pipe work shall be stress relieved and radiographed.

(j) Valves for Liquid Chlorine

Valves for liquid chlorine duty shall be Polytetrafluorethylene sleeved plug type 2-way valves with carbon steel body and Monel plug.

Where the valves are manually operated, they shall be wrench situated with padlock type locking feature.

Power actuated valves shall have electric actuators with built in position feedback limit switches, torque overload protector, IP 56 enclosures and manual override facilities.

(k) Chlorine Pressure Gauges

Pressure gauges for use with chlorine shall be of the Bourdon tube type with a special diaphragm isolating the tube from the liquid or gaseous chlorine. Pressure gauges shall have dials not less than 150 mm diameter except where they form an integral part of equipment, such as a chlorinator. No aluminium shall be used in the construction of the gauges; the dials and bezels shall be of bronze and internal components shall be of a stainless steel or other alloy or Corrosion resistant material against chlorine usage.

All pressure gauge piping shall include isolating valves at each point of connection to the main piping.

Where necessary, pressure gauges shall be fitted with adjustable electrical contacts for initiation of alarm conditions with either rising or falling pressure, to suit the system design.

(l) Automatic Drum Changeover Panel

The automatic drum changeover panel shall be a specially designed unit capable of selecting liquid chlorine containers for duty on an alternate basis. The unit shall be capable of working in conjunction with four liquid chlorine drums (two duty, two standby).

The panel shall satisfy the following duty functions in chronological order:

Check pressure in the line initiate automatic changeover and alarm if pressure is low;

Shut the delivery valve of the drum that has just become empty and open the valve of the standby drum on line;

Re-check pressure as in (1) above and initiate alarm if pressure is still low;

Proceed until next changeover is initiated, then repeat the sequence;

At each step, the operation of valves shall be monitored using position feedback limit switches and valves failing to operate in a set time shall immediately initiate an alarm.

(m) Chlorine Gas Pipe Work

~~Pipe work conveying chlorine gas shall be solid draw steel tube to B.S.1387 with BSP taper threads to B.S. 21. All fittings shall be of malleable iron. Chlorine gas pipe work shall be adequately supported. Threaded joints shall be sealed using jointing compound compatible with chlorine. Poly tetrafluoroethylene tapes shall not be acceptable.~~

~~Where installation involves injectors to be located near the dosing points or remote injectors, the vacuum chlorine gas delivery lines downstream of chlorinators shall be of uPVC or approved equivalent and the lines to be run in RCC ducts with proper Pre cast covers.~~

~~(n) Chlorine Gas Valves~~

~~Valves for gaseous chlorine duty shall be specifically designed for chlorine with forged steel bodies, Monel valve packing or special diaphragm in chlorine resistant materials.~~

~~(o) Chlorine Gas PRV and Shut-Off Valves~~

~~Chlorine Gas Pressure Reducing and shut-off valve shall be a spring loaded, diaphragm operated valve with super-imposed electric actuator designed to reduce varying gas pressure upstream to a desired regulated pressure downstream and maintain this pressure within close limits.~~
~~The diaphragm shall be made of Polytetrafluorethylene (PTFE).~~
~~The electric actuator shall ensure quick shut-off of the gas flow in the event of a breakdown or similar event.~~

~~(p) Injector Motive Water Supply System~~

~~Injector water supply system shall be compatible with the flow and pressure requirements at the maximum rated output of the chlorinators offered and to limit the chlorine solution concentration to an acceptable limit at operational fluid temperature up to 330 C.~~

~~(q) Chlorinators~~

~~The chlorinators shall be vacuum operated aqueous solution feed type units working in conjunction with wall mounted injectors.~~
~~The units shall be discrete floor standing cabinets of plastic/composite construction. The chlorinators shall be suitable for manual feed rate control~~

and incorporate a flow metering device for precise regulating of chlorine gas over a 20:1 flow range, with a metering accuracy of plus or minus 4% of the indicated gas flow rate.

Each chlorinator shall be fitted with the following principal components;

a) Gas inlet pressure regulating valve.

b) Pressure/vacuum relief valve with safety vent.

c) Vacuum regulating valve.

d) Gas feed rate regulator preferably of the 'V' notch cylindrical plug and variable area orifice type.

e) Variable area type flow meter with linear feed rate indicator calibrated in kg/hr

f) Thermostatically controlled gas inlet heater

g) Wall mounted injector, preferably of adjustable throat type

h) Rigid PVC pipework to wall mounted remote injectors.

i) Chlorinators shall be provided with panel mounted indicators for the chlorine gas inlet pressure, injector vacuum, motive water pressure, chlorine solution pressure immediately downstream of injector and a feed rate adjustment knob.

j) Chlorine gas feed piping shall be provided with valves to allow isolation of each chlorinator without disturbing the operation of the other chlorinators.

k) Rigid PVC chlorine vent piping shall also be provided and arranged to discharge at a high level outside the room housing the chlorinators to ensure safe atmospheric dilution.

l) The chlorine supply to the injector shall shut down automatically if:

- The water supply to the injectors shall fail
- The injector vacuum line should break
- The chlorine solution line should be accidentally shut down by the closing of a chlorine solution dosing valve.

m) A check valve shall be provided between chlorinator and injector to prevent accidental backflow into the chlorinator. This shall be consistent with the injector design with respect to gas flow and water pressure. While effectively preventing backflow, this valve shall allow requisite gas flow.

n) Additional safety devices shall be incorporated in the equipment to prevent hazards to the operators or damage to the components under normal operating and shutdown conditions.

o) All electrical services and control signal lines (where applicable) shall be wired to a single termination board within the chlorinator cabinet. The termination board shall preferably be totally enclosed in a gas-tight junction box with glanded cable entries and fitted with a clearly labelled warning sign stating the supply voltage. Electrical supply isolating switches interlocked with the panel doors shall also be provided in each chlorinator cabinet.

(r) Chlorine Draw-Off System

Chlorine shall be drawn off as gas; to minimize drum handling there shall be adequate connections and drum isolating valves provided to enable one drum from each row to be connected to the automatic drum changeover device to be provided under this Contract.

The local supply of liquid chlorine may contain 0.1% to 0.2% ferric chloride and about 50 mg/l moisture. Tenderers shall provide for suitable devices such as filters so that the pipe work and equipment are protected against deposits or corrosion.

The duty/standby drums shall be located on plinth mounted casters with four rollers per set or drums. The casters with rollers for these drums shall be supplied and installed under this Contract.

The installation shall include all necessary chlorine headers including supports, power actuated valves and manual isolating valves, for connection of drums to the drum changeover device.

The liquid chlorine pipe work interconnecting the drums, changeover panel and the liquid chlorine evaporator shall be safeguarded by a pressure relief system.

The pressure relief system shall comprise locked open isolating valves, bursting disc assembly, pressure gauge with adjustable alarm contacts and relief vessel.

The bursting disc shall preferably be made of nickel sheathed in PTFE, or approved equivalent.

(s) Chlorine Solution Delivery Pipe Work and Valves

The Contractor shall provide all necessary rigid pipe work, valves and fittings for the delivery of the chlorine solution from chlorinator injectors/manifold to the points of application.

~~The chlorine solution delivery lines shall be of Mild steel ebonite lined or approved equivalent. The pipe work shall be adequately protected externally against corrosion and installed complete with necessary supports, thrust restraints, etc., and incorporate sufficient flexibility to allow for any thermal expansion effects.~~

~~When selecting material for pipe work, consideration shall be given to the deteriorating effect on some synthetic materials due to the action of ultra-violet rays. Where such materials are employed, particularly in the case of uPVC, pipe work shall be shielded from direct sunlight.~~

~~The valves in the chlorine solution pipe work shall be of cast iron body, flanged, rubber lined valves of the diaphragm type or approved equivalent. Locking devices and position indicators shall be provided. The diaphragm of the valves shall be PTFE faced with a backing of viton synthetic rubber (co-polymer of vinylidene fluoride and hexa fluoropropylene).~~

~~Test pressure for the solution delivery pipe work, valves and specials shall be twice the working pressure or 1 1/2 times the shut off head of the injector motive water pumps, whichever is higher.~~

~~(t) Chlorine Solution Distributors & Injection Fittings~~

~~Where chlorine solution is to be dosed into flow in an open channel, chamber or downstream of a hydraulic jump it shall be applied using a chlorine solution distributor.~~

~~The distributor shall be either tube drilled ceramic tubular diffuser, designed to ensure uniform distribution of the specified flow rate of chlorine solution at the point of application.~~

~~The materials of construction of the distribution and sealing shall be compatible with 3500 mg/l chlorine solution at operational fluid temperature up to 30°C. Porous ceramic material where used shall be inert, and non-toxic, uPVC tube where used shall conform to BS:3505 Class 'E'.~~

~~The distributor shall be adequately supported and designed to withstand the stream velocity at the point of application and any flow or turbulence induced vibrations.~~

~~Where chlorine solution is to be dosed into flow in pipe lines it shall be applied using an injection fitting/device designed for specified duty flow rate.~~

~~The injection tube shall extend across the pipe bore and be supported with ends located in diametrically opposite flanged branches.~~

~~The injection fitting shall be installed in diametrically opposite flanged branches with their axis making an angle of 45° with the horizontal in a plane normal to the direction of flow within the pipe line.~~

~~The injection fittings shall be adequately supported and designed to withstand the flow or turbulence induced vibrations. Provisions shall include necessary support brackets also.~~

~~Chlorine solution distributors or injection fittings shall be supplied complete with necessary non return and isolation valves.~~

~~(u) Tonner Roller Supports~~

~~These supports shall be used to hold the Tonner containers securely in place and also to facilitate the positioning of the Tonners, so that inbuilt valves (Gas side and Liquid side)~~

~~The Roller support body shall be made of Cast Iron, rollers shall be Cast Iron/Mild steel, Bushes shall be of Brass and Rollers shall be carbon steel with cadmium plated.~~

~~(v) Lifting Beam with Hooks~~

~~To facilitate safe lifting of standard Tonner container, the lifting Beam with hooks shall be provided. The Beam shall hold the Tonner securely while hoist and Trolley are used to lift, place and position the containers. The Beam material shall be Cast Iron/Mild steel.~~

~~(w) Chlorine Plant Ventilation~~

~~The Container Store area and the Chlorinator Room shall be made reasonably gas tight and provided with separate forced ventilation facilities. A ducted system shall be provided with a number of fan units such that even though any one unit fails reasonable ventilation would still be effected.~~

Inlets to the exhaust duct system shall be placed at the floor level. The exhaust system shall directly discharge air to atmosphere outside the building.

Each exhaust system shall include two sets of fans, one for continuous running giving 4 air changes per hour and the other designed for intermittent running giving 20 air changes per hour.

Movable louvers shall be provided on the inlet and outlet ports of the forced air circulation system. The louvers shall open automatically when the ventilation is started and closed by gravity when stopped. Contactor starters for operating ventilation equipment shall be provided in the motor control center in the Office and Control Room as well as local to the units, and be subject to shut-down control from leak detection units. Ductwork (Minimum 400mm ID) shall be manufactured from Aluminum sheets/PP (3mm) +FRP (5mm) in circular or rectangular sections.

All necessary ducting, self-closing louvered outlets, exhaust fans with external mounted control gear indicator lights shall be provided under the Contract. Special attention shall be given to materials of construction and particularly to motor protection.

(x) Chlorine Container Weighing Equipment:

Equipment provided for weighing chlorine containers shall be spring type loaded with circular scale indicator and shall conform to IS: 1438.
The weigher shall be designed suitable for suspension from the load hook of Lifting Beam to be properly secured to the crane or hoist.

The weigher shall be suitable for operation with a working load of not more than 2000 kg. The indicator scale shall be calibrated in 5kg divisions, with the zero at the top of the scale and the pointer vertical with no load. The pointer shall incorporate means of tare adjustments up to 20% of the indicator scale. The indicator dial shall be slanted from the vertical plane so as to minimize parallax errors when the indicator is read from the floor with the unit hoisted to a high level.

The weigher shall have an overall accuracy of better than 10% of the full scale deflection and the unit shall be unaffected by the temperature variations in the range 4 to 50°C.

Bidders are encouraged to propose Digital type weighing Equipment and shall be subject to approval by the Engineer.

(y) Safety Equipment:

Materials and equipment necessary to ensure the safety of personnel operating the chlorination plant and others shall be provided.

The equipment shall include inter alia:

i. Two sets of approved self contained breathing apparatus, each comprising an air set, carrying harness, face mask and valves and ancillary equipment. Each set shall be provided with three 1 200 litre capacity, 140 mm diameter, air cylinders;

ii. Two sets of approved positive airline breathing apparatus, each comprising body harness, face masks and valves and 30 m of airline. One air trolley, comprising wheeled frame with two air cylinders, control manifold, airline hose and hose winding drum. Two spare cylinders suitable for changeover shall be provided;

iii. one portable electric motor driven air compressor for recharging air cylinders, complete with quick-release air hose couplings;

iv. Two `instant action' resuscitators.;

v. Four sets of safety clothing in various sizes, each comprising PVC overalls, wellington boots with steel toe caps, goggles, gloves and safety helmets.

Each set of safety equipment shall be mounted in a glass fronted, non locking PVC coated steel cabinet in approved locations on the outside of the Chlorine building.

Two emergency showers shall be provided and shall be installed outside on either side of the Chlorine drum room.

Each shower shall be operated automatically by a quick acting hand or foot valve.

Four eyebaths shall be supplied. Two eyebaths shall be adjacent to each of the showers. The eye bath unit shall be fitted with fine mesh filters with built in pressure regulating device to ensure a safe rate of flow to prevent foreign matter being further embedded into the eye and instead flush away contamination

Water for the showers, etc, shall be drawn from the service water supply.

~~A telephone will be provided close by outside the building for emergencies.~~

~~(z) The Tonner Room~~

i. ~~Storage shall be provided for chlorine tonners sufficient for at least one month's usage at normal rates of application.~~

ii. ~~The system shall be designed to prevent freezing of the liquid chlorine at the maximum rate of withdrawal.~~

iii. ~~Tonners online, tonners on standby and full and empty tonners, shall be stored separately in the tonner room.~~

iv. ~~Tonner rollers shall be provided. Tonners not in use shall be stored on concrete cradles.~~

v. ~~A 3 tonne overhead single girder electric travelling crane shall be provided in the chlorine tonner room for the following functions:~~

~~(1) Offloading (and reloading) of tonner from trucks;~~

~~(2) Handling of tonners within the storage area.~~

vi. ~~The system shall serve the tonner store width over the entire length including the loading/ unloading area.~~

vii. ~~The hoist and traverse speeds shall be as follows ;~~

~~(1) Long traverse speed : 6 m/min~~

~~(2) Cross traverse speed : not more than 3 m/min~~

~~(3) Slow lifting speed : 1m/min~~

~~(4) High lifting speed : 2 m/min~~

viii. ~~The container lifting beam shall be specifically designed for handling chlorine containers and equipped with necessary shackles and hooks.~~

ix. ~~Operation of crane system shall be from the floor level using independent push button pendant controls operating at a 230 volt 50 Hz AC supply.~~

x. ~~Two lifting beams shall be provided (a duty and a spare) and a one tonner weigher to be suspended from the crane hoist.~~

xi. ~~When the pressure in the duty chlorine tonner falls to less than 1 kg/cm2 the automatic changeover device shall operate to isolate the empty tonner and to bring the full standby tonner on line.~~

xii. ~~A pit and alkali absorption system shall be provided to contain and neutralise chlorine in the event of a leak. The system shall comprise a pit located in the tonner storage room, suitable pump in SS CF8M material and accessible by the overhead crane system. The pit shall be surrounded~~

with removable guard railing. The pit shall be kept full with a neutralising solution of lime. The pit shall be capable of holding side by side two chlorine tonners. A provision shall be made to drain the pit.

xiii. In addition to the above Automatic chlorine leak absorption system (Gas Scrubber with NaOH dosing) shall be provided adjacent to the Tonner room. The process shall be designed to contain and neutralize chlorine gas vapours in response to gas leak or catastrophic cylinder failure. The system should be able to absorb 99.99% of the chlorine gas entering the scrubber.

xiv. The scrubber system shall be provided with FRP tower chlorine leak absorption system with FRP frontal hood for chlorine tonners, uPVC Ducting as per site condition, blower with two Nos. motors (1W+1S), Pressure gauge with isolation valve on blower outlet, Motorised Damper on suction side, Manual Damper on suction side, PP-FRP caustic recirculation tank, one no. level gauge on tank, one no. Dissolving basket and level switch on tank., PP diaphragm valve for drain and water inlet, One no. PP tower with packing , pump suction and strainer for pump suction, uPVC pipe on caustic pump suction of required length as per site condition, caustic recirculation pump with motor with two Nos.(1W+1S), PP diaphragm valve on caustic pump delivery, check valve on caustic pump delivery, uPVC pipe with fitting on caustic pump delivery as per site condition, pressure gauge with isolation valve on each pump delivery.

xv. When a leak occurs, the pump and fan shall start automatically. The fan shall provide sufficient vacuum to contain the chlorine gas and deliver it to the scrubber. The pump shall circulate the concentrated caustic solution over the scrubber packing to absorb all the chlorine gas.

xvi. Special consideration shall be given to any floor drainage system in the tonner building; adequate traps shall be provided to ensure that chlorine gas cannot escape. All leader tubes carrying cables or pipes out of the building shall be sealed at either end to prevent any chlorine gas leaking out.

(aa) Motive water pumps and Injector

(a) Motive water pumps (1 working + 1 standby) shall be installed.

(b) The pumps shall draw their supply from bore well/plant water supply.

(c) The pumps shall be installed outside the chlorination room and shall be made from material resistant to corrosion by chlorine.

(d) Two injectors shall be provided, each serving a duty / standby pair of chlorinators. The injectors shall be located near point of dosing i.e. upstream of Chlorine contact tank.

(bb) Chlorination Room

(a) The chlorination room shall be constructed adjacent to the tonner room but with no interconnecting door or other form of access. Chlorine injection equipment and gas cylinder shall be installed indoors.

(b) Gas lines from the tonner room into the chlorination room shall run in ducts to be sealed after installation and prior to commissioning.

(cc) Chlorine Leak Detectors

Not less than three chlorine gas leak detectors shall be provided each, with a single detector cell. At least two sensors shall be located in the chlorine tonner storage room and at least one sensor in the chlorination room. The chlorine leak detectors in the tonner room shall be mounted at each end of the tonner room.

a) The chlorine leak detectors shall have two adjustable alarm levels sensitive to chlorine concentrations above 1 mg/m3. The range of adjustment of alarm levels shall facilitate selection of the following alarms:

(1) low level 2 mg/m^3
(2) high level 4 mg/m^3

The low level alarm shall:

(1) Initiate a local audible and visual alarm;
(2) Start the ventilation fans in the tonner and chlorination rooms;
(3) Raise an alarm at the local control panel and at the central MMI.

The high level alarm shall:

(1) Initiate local audible and visual alarm;
(2) Initiate audible and visual alarms outside the buildings (the alarm shall be sufficiently loud to be heard in all buildings at the WWTP);
(3) Raise an alarm at the local control panel and at the central MMI;
(4) Shut down the chlorination systems;
(5) Stop the tonner room and chlorination room exhaust fans.

(b) The chlorine detectors shall have self-checking circuitry and detector failure alarms shall be provided at the local control panel and central MMI.

(c) Detector failure alarms shall not be combined with the leak alarms. Pilot lights and warning sound generators shall be installed in outdoors to notify gas detection.

(d) Statutory warning notices relating to the storage and handling of chlorine shall be provided. The signs shall be pictorial and provided in Kannada and English.

(dd) Chlorine Residual Monitors

(a) Chlorine residual monitors shall be provided at the plant outlet.

(b) The monitor installation shall be located in a covered location easily accessible for viewing and maintenance and shall be provided complete with sample pumps as necessary to ensure the continuity of the sample.

(c) The sampling pipe work complete with isolation valves etc. shall be designed to ensure the sample reaches the monitor in a time not greater than 1 minute. The monitor drainage pipe work shall permit the visual checking of the presence of flow and shall discharge to the foul drain. Sample sewage not passed through the monitor shall be returned to the process.

(d) The residual signals shall be displayed at the local control panel.

(e) High and low chlorine residual levels shall raise alarms at the local control panel.

(ee) Chlorination Power and Control

(a) A combined MCC and control panel shall be provided and located in a suitable location protected from the weather and the effects of the process. The control panel shall provide facilities for:

(1) Display status and values associated with the chlorination systems;
(2) Duty pump selection;
(3) Annunciate alarms associated with the chlorination systems;
(4) Operator adjustment of process set points.

(b) The chlorination systems shall operate using a fixed manually set dose rate. The quantity of chlorine dosed will therefore be adjusted in direct proportion to the process flow at the dosing point.

(c) The chlorine residual monitors to be provided shall be used for monitoring and alarm purposes only.

8.19Disc Filter

The disc filters Partially submerged shall be gravity fed and should be capable of filtering effluent from secondary clarifiers and achieve the desired filtered water quality as follows.

Design inlet TSS, ppm : 20 ppm
Design Inlet TSS loading factor: 1.5.
Design outlet TSS, ppm : < /= 10 ppm
Total backwash water required: Shall not exceed 5% of the design influent flow.

The filters should be sized for peak flow.

The disc filters shall be furnished and installed in a free standing in concrete basin and shall include filter discs made up of individually changeable filter panels mounted on a filter drum. Each panel shall have a SS 316L with 10 microns mounted on a SS316/Poly Propylene Glass/ABS frame.

The filters shall include a gear motor/drive chain, stainless steel rotating drum with synchronous reduction gear and the chain/Timer Belt, Stainless Steel inlet channel, SS 316 Tank covers and level control mechanism. The filter shall also be supplied with a backwash system complete with pump, piping, spray pipe nozzle, control and all other accessories as required complete. All wetted metallic parts will be in SS 316 construction. Access walkways, hand railing and Staircases etc. shall be provided as defined in the tender specifications. The disc filtration unit shall be covered with Roof.

CONSTRUCTION:

a. **Center Drum:** The center drum shall be watertight, structurally welded and fabricated, stainless steel piece that open at one end to allow the influent to enter and shall have openings to the filter discs for distribution to the filter cloth. The drum shall have lubricated bearings externally accessible for routine lubrication.

b. **Disc Assembly:** Each disc will be made up of easily removal filter panels made of SS 316L with 10 microns, mounted on a SS 316/Poly Propylene Glass/ABS frame. Gaskets will be provided to seal all gaps to prevent water leakage. Each panel will filter the effluent independently without any carry over to adjacent panels in order to maintain a high filtration efficiency.

c. **Filter Cover (Hood):** The disc filters shall be furnished with SS316 cover with safety locking system for the purpose of service and inspection.

d. Backwash Cleaning System: Each Disc will be provided with a dedicated set of backwash spray nozzles in ceramic /engineered Plastic. Filtrate will be used as the backwashing medium. Self-cleaning nozzles should be used for continuous operation. Alternatively, a 200 micron filter should be used to filter the water going to the spray nozzles to avoid nozzle clogging. A multistage high-pressure pump with dry run protection will be provided for each filter. A level sensing mechanism will be provided to sense the hydrostatic head differential between the inlet and outlet of the filter and activate the backwash cycle.

e. Drive Mechanism: The disc filter drive shall consist of a motor with a helical worm gear and a drive chain/Timer Belt. The drive will be frequency controlled (VFD). Each filter shall have only two motors, one for the main drive and one for the backwash pump.

f. Control Panel: The filter will be configured for a fully automatic operation through a control system. The Panel shall be with a minimum IP 55 protection.

g. Spare Media: The contractor shall maintain SS316 media one unit of Disc as spare for each equipment for O&M Period.

OR

Disc Filter- fully Submerged

The disc filters shall be gravity fed and should be capable of filtering effluent from secondary clarifiers and achieve the desired filtered water quality as follows.

Design inlet TSS, ppm: 20 ppm

Design Inlet TSS loading factor: 1.5

Design outlet TSS, ppm : < /= 10 ppm

Total backwash water required: Shall not exceed 5% of the design influent flow.

The disc filters shall comprise multiple high strength and separate disc. Each disc shall be sub divided into smaller sections to constitute a prefabricated disc frame so as to ensure easy replacement and maintenance. Each disc consists of multiple panels. Each disc shall be mounted on the center drum by thread rod and strap band for the exact roundness.

The drive part of disc filter shall be of worm geared type with motor chain drive. Power shall be transmitted by SS316 chain. A protective cover made up of SS316 shall be equipped for the driver material, reduction gear and the chain/Timer

Belt. Each disc will be made up of easily removal filter panels made of SS 316L with 10 microns, mounted on a SS 316/Poly Propylene/ABS frame.

Backwash system, cleaning device consists of suction cleaning unit, which conduct the suction cleaning in each side of the disc, the automatic valve and suction cleaning device shall clean the SS 316L thoroughly by the suction unit on both side of the disc with automatic valve and suction cleaning pump which shall be activated by the water level switch that contacts the water level raised with the increase of the loss of head. Disc filter shall be operated for the filtration without the stop during backwash and suction of sludge. Suction cleaning unit shall be made of or the even cleaning efficiency without dead zone for all area of filter mesh. SS316 media one unit of Disc as a spare for O&M for each equipment.

Control panel shall be SS-304 / SS-316 double/single door (inner & outer door), IP55, self-standing, floor mounted type in case of is outdoor. Control panel shall contain PLC, HMI, circuit breaker etc.,

Control panel shall accommodate an inverter/VFD to control the rotation velocity of the disc drive.

The drums shall be round type and shall have enough area in order to discharge the treated water without trouble. The material of the filter nominal pore size of 10 micron.

Central drum and Shaft shall be SS316. Mix filtration rate shall be minimum 10 m3/m2/hr.

Technical Particulars Common for both Partially Submerged or Fully Submerged type Disc Filtration System		
Design Inlet Flow (Average)	:	As per process design
Design Inlet Flow (Peak)	:	As per process design
No. of streams / disc filter units	:	As per process design
Inlet TSS	:	20 ppm
Outlet TSS	:	</= 10 ppm
Backwash Water Use	:	</= 5% of Influent
Type of Filtration Media	:	Stainless steel AISI 316
Filter Membrane	:	Stainless steel Screen / Mesh: SS-316L.
Size of Filtration / Filter membrane pore size (micron)	:	10 microns Max. or smaller as per vendor recommendation
Mounting	:	Horizontal
Filtration direction	:	In to Out / Out to In
Filter wheel diameter, mm	:	As per vendor design
Number of filter frames per wheel, Nos.	:	As per vendor design
Number of filter wheels, Nos.	:	As per vendor design
Type of Backwash Pumps	:	Horizontal or vertical mounted High Pressure Pump for effective backwash
Cleaning Method	:	Nozzle Spray type (Partially Submerged)/ Suction type (Fully

		Submerged)
Required Field Instruments	:	Radar type level transmitter, Conductivity level switches (4 Point Contact) in each disc filter and Turbidity sensor for disc filter outlet
Spare Media shall be supplied for O&M	:	SS316 media one unit of Disc
MOC of Major Disc Filter Components		
Rotor / Centre drum / Distributor	:	SS-316
Protective Top cover and Body cover along with frame structure	:	SS-316 (Minimum 4 mm for Body cover)
Spray Nozzles	:	SS-316
Backwash Piping	:	SS-316
Drive Mechanism	:	Reduction Gear SS 316 reduction gear and the chain/Timer Belt and contractor's has to maintain the minimum one spare during the O&M period to avoid longer downtime of the unit.
Canopy for Main drive	:	SS-316
Control panel		
Type	:	Self-standing / Wall Mounting type, PLC based controls with HMI Screen of 10 inches. PLC shall be provided with Hardwired communication protocol interfacing with Plant SCADA system.
MOC of control panel	:	Stainless Steel SS-304 / SS-316
Protection Class	:	IP-55 & suitable for outdoor mounting.

8.19 Plant Drainage Pump set

(a) The total head capacity curve shall be continuously rising towards the shutoff with the highest at shut off.

(b) The pump shall run without undue noise and vibration.

(c) The power rating of the pump motor shall not be less than the power required from zero discharge to zero head.

(d) Pump shall be submersible type with double mechanical seals. Motor shall be of IP 68 protection.

(e) It shall be suitable for handling turbid water. Pump and motor shall have common shaft.

(f) Delivery pipe of drainage pump sets shall be of size 40 NB and as per IS 1239, heavy class. Required length of pipes and fittings shall be provided. Pumping main shall be common for two pumps.

(g) Level switch to start and stop the pump automatically shall be supplied with the pump. A level indicator shall also be provided.

(h) The capacity, total head and range of operating head of drainage pump set shall be as specified in particular mechanical requirements.

(i) The material of construction of pumps shall be as follows:

S. No.	Component	Material
(i)	Impeller	Stainless Steel :ASTM 743 CF8M
(ii)	Casing	Cast Iron : IS 210 Gr. FG 220 or 260
(iii)	Shaft	Stainless Steel: BS:970 GR 410

8.19Facility used for domestic water

This facility shall be installed as a daily water supply facility in offices, water quality analysis rooms, etc.

Water supply pipes shall be installed in office water / shower water / toilet / water quality analysis lab water / chemical dissolving water / machinery facility cleaning water / flower bed water.

In addition, a septic tank shall be installed as a wastewater treatment for domestic water used.

1) Install a water meter.
2) Install an underground receiving concrete tank
3) Water to the elevated tank with a booster pump.
4) Install a septic tank.
5) Return the drainage to the grit chamber.

8.20 Maintenance facility using treated sewage water

The cleaning water necessary for the maintenance of the facility shall be equipped with cleaning facilities that can use sewage treated water in order to conserve tap water.

The main destination of cleaning water is vehicle cleaning / sewage treatment tank / watering.

1) Consider the following items for the construction of cleaning water facilities.

- Measures to ensure hygienic safety for workers
- Measures to prevent corrosion and blockage of facilities
- Measures to prevent misconnection with domestic water
- Measures to prevent erroneous beverages

2) A concrete washing water tank that can use storage and sewage reuse water shall be constructed.

3) Pump for cleaning water supply shall be operated at the necessary time.

4) A facility that is easy to clean shall be constructed.

5) Submersible Pumps with a water level sensor shall be installed in all drainage drain pits provided in all structures.

6) The drainage pumped up shall be discharged in wet well.

8.21 Fire Extinguishers

(a) Portable fire extinguishers are to be provided for all units as per the requirement of Tariff Advisory Committee (TAC) or meeting the requirement of local regulations whichever is more stringent.

(b) All the extinguishers shall be of TAC approved.

8.22 Propeller Exhaust Fan

(a) The fan should comply with IS 2312.

(b) The blades shall be of mild steel and properly balanced so as to avoid noise and vibration.

(c) The blade and blade carriers shall be securely fixed so that they do not loosen in operation. The means provided for securing the fan mounting or fan casing to the wall partition or window shall be such as to provide a secure fixing without damage to the fan or wall.

(d) Suitably designed guards shall be fitted to the inlet and the outlet side to prevent accidental contact. No flammable material shall be used in the construction of fan. Moulded parts, if used, shall be of such materials as to withstand the maximum temperature attained in the adjacent component parts.

(e) The fan shall have protective insulation or be capable of being earthed. A fan with protective insulation may be of all insulated construction or have either double insulation or reinforced insulation. Each fan should be provided with a 10 sq.mm mesh bird screen. The sheet used for the cowl should be 14 G.

8.23Forced Fresh Air Circulation System

Fresh air circulation system is to be provided for the raw sewage pump house and Blower room for circulation of fresh air to limit increase in temperature and also avoid stale air presence. The complete system along with all associated required air supply fans, exhaust fans, ducts, grills, galvanized bird screens, hoods and all necessary accessories shall be provided. Suitable arrangements to prevent ingress of rain water into building shall also be provided. The system shall be designed with required air changes and the contractor shall provide detailed calculations to determine the air capacity, static pressure etc. and relevant technical details for the approval of Engineer.

All duct work shall be of high quality approved galvanized sheet steel guaranteed not to crack or peel on bending of fabrication of ducts.

The ducts shall be fabricated from galvanized plain steel sheets conforming to IS: 277-2003. All duct work, sheet metal thickness and fabrication, unless otherwise directed, shall strictly meet requirements as described in IS: 655.

All joints shall be tight and shall be made in the direction of air flow. The ducts shall be reinforced where necessary and must be secured in place so as to avoid vibrations of the duct and its supports.

Volume control dampers shall be of an approved type, lever operated and complete with locking devices which will permit the dampers to be adjusted and locked in any position.

Exhaust fans of appropriate rating shall be provided for pumping stations. The contractor shall submit the fan selection details for approval.

For axial flow fans / propeller fans, speed limitation shall be as follows:

For impeller diameter of up-to 450 mm – maximum speed shall be 1500 rpm.

For impeller diameter above 450 mm – maximum speed shall be 1000 rpm.

Suitable designed guards shall be fitted to the inlet and the outlet sides to prevent accidental contacts. No inflammable material shall be used in the construction of fans.

Drive motors shall be rated at least 15% higher than the power requirement at duty point or 10% higher than the maximum power requirements at the selected speed, whichever is higher. Motor shall be conforming to TEFC, IP 54 protection.

8.24Air-conditioning Equipment

The air conditioning units shall be of split type, with the outdoor condensing unit mounted on the terrace of the room or grouted on external side of the wall with suitable brackets.

8.25Air Hose Apparatus

It shall consist of full vision face mask with inhalation and exhalation valve, connected to a corrugated tube ending in a manifold non-return valve, mounted on a harness belt worn around the waist, tested to BS 1397. The 50m long, 20mm canvas reinforced wire embedded hose, connected to the manifold shall be uncrushable and shall not kink.

The radial blower connected to the hose shall be housed in a strong carrying box which can hold the breathing apparatus with hose and fittings. The blower shall be suitable for supplying air to two people simultaneously.

8.25Surge ~~Protection System~~

~~The Contractor shall carry out comprehensive transient or surge analysis of the complete pumping systems considering full length of pipelines under all operating conditions. The surge analysis shall be carried out using a proven and acceptable computer programme which is being used in water supply industry. The surge analysis report shall be approved by the employer. The surge analysis shall identify the most adverse transient conditions. The analysis shall include but not be limited to the following conditions:~~

- ~~Tripping of all duty/working pumps (running at maximum capacity) due to complete power failure for all operating conditions.~~
- ~~Start up of the pumps under the specified control system~~
- ~~Shut down of the pumps under the specified control system~~

~~The objective of the surge analysis is to recommend surge protection devices which ensures maximum and minimum allowable pressures under the operation conditions. After power failure to pumps the following design criteria shall be adopted for assessing the transient pressures:~~

~~a) The maximum transient pressure shall be less than the pipeline design pressure which in about 1.5 times the working pressure.~~

~~b) The negative pressure of the pipeline shall be restricted to 1/3 of atmosphere pressure or less.~~

~~The recommended solutions should include sensitivity checks to show that it is still valid with possible variations in system parameters such as wave speed, friction factor and system demands.~~

~~The Contractor shall submit the surge analysis report to the employer for approval. The report shall include computer analysis and graphs showing maximum and minimum transient pressure envelopes with and without surge protection devices. The report shall also include time-flow and time pressure plots at critical points with graphs and tables which shows surge control requirements shall be met by proposed measures.~~

8.26Valves

(a) Valves shall be as per internationally recognized standards. Flanges shall be machined on faces and edges. Flanges shall conform to ISO 7005, IS 6392, BS EN 1092-1/ BS 4504.

(b) Valves shall be double flanged type and the faces shall be parallel to each other. The flange face should be at right angles to the valve centre line. Back side of valve flanges shall be machined or spot faced for proper seating of the head and nut.

(c) Valves buried or installed in underground chamber, where access to a hand wheel would be impractical, shall be operated by means of extension spindle and/or keys. Wherever extension spindle is provided, the valve shall also be provided with suitable headstock.

(d) Valve of diameter 450 mm and above shall be provided with lifting eyes and shall have detachable bolted covers for inspection, cleaning and servicing.

(e) Valve shall be suitable for frequent operation as well as operation after long periods of idleness in either open or closed position.

(f) The valve stem, thrust washers, screws, nuts and all other components exposed to the water shall be of a corrosion resistant grade of stainless steel.

(g) Valves shall be free from sharp projections which are likely to catch and hold stringy material.

(h) All the valve shall be of 10 bar rating.

(i) All the valves on the suction and delivery side of the Intermediate and Terminal sewage pumping station shall be of Motorized Knife gate type.

(j) All valves in the plant shall be provided with dismantling joint/Flexible joint/SS bellows for ease dismantling.

(k) All the valves on the suction and delivery side of the Primary sludge, Return & Waste Activated Sludge, Thickened Sludge, Centrifuge sludge feed, Digester sludge recirculation, Digester feed and all sewage & sludge handling pumping system and for all sludge application in the plant shall be of Manually operated on suction side and Motorised Knife gate type on delivery side of the pump set.

(l) ISPS and TSPS Pumping main shall be installed with Kinetic Air valve with isolation sluice at High points and Sluice valve as Scour connection at Low points.

(m) All the valves shall be provided with Bypass valve arrangement 10% of main valve size.

(n) 2 sets of ladders shall be provided in the raw sewage pumping station to facilitate access of valves.

(o) Telescopic valves shall be provided in sludge storage tanks for sludge withdrawal purpose.

(p) All the sludge and chemical lines shall be installed with flushing connection with ball valves for maintenance.

(q) For all gas service and process air application the valve shall be Butterfly valves in Resilient seated (Bio Gas/Gas service) and Metal-Metal Seated (for process Air service).

8.2~~3~~6.1 Electric Actuator

(a) All local controls shall be protected by a lockable cover.

(b) Each actuator shall be adequately sized to suit the application and be continuously rated to suit the modulating control required. The gearbox shall be oil or grease filled, and capable of installation in any position. All operating spindles, gears and headstocks shall be provided with adequate points for lubrication.

(c) The valve actuator shall be capable of producing not less than 1½ times the required valve torque and shall be suitable for at least 15 minutes continuous operation.

(d) The actuator starters shall be integrally housed with the actuator in robustly constructed and totally enclosed weatherproof housing. The motor starter shall be capable of starting the motor under the most severe conditions.

(e) The starter housing shall be fitted with contacts and terminals for power supply, remote control and remote positional indication.

(f) Each starter shall be equipped as follows :

(1) 2 No. Three phase magnetically operated line contactors with no-volt release and electrical and mechanical interlock.
(2) 1 No. Three phase thermal cut-out device.
(3) 1 No. Control circuit transformer fully protected by fuses on primary and secondary circuits.
(4) 1 No. Set of “Open”, “Close” and “Stop” buttons.
(5) 1 No. Local- Off-Remote switches with padlocking facilities.
(6) 1 No. Set of torque and limit switches for “Open” and “Close” positions.
(7) 3 No. Sets of auxiliary limit switches in each direction.
(8) Valve position Analog Transmitter (i.e. Actuator accept To Read Analog signal from Actuator to PLC and also To Write Analog Signal from PLC to Actuator) & mechanical indicator and hand wheel for manual operation.
(9) Reduction gear unit
(10) Trip signals of Thermo switch, Torque Switch and Thermal Overload Relay shall be provided for Indication and also integrated to PLC.

8.2~~3~~6.2 Butterfly Valve

Butterfly valves shall be of double eccentric and resilient seated type generally as per BS EN 593 and IS 13095.

Butterfly valves shall be suitable for bi-directional pressure testing. The valves shall be of double flanged long type.

The valves shall be electrically/pneumatically/manual operated to suit the process requirement mentioned elsewhere in this tender document. The valve shall be free from induced vibrations. Valve shall be suitable for mounting in any position.

The valve seat shall be of metal to metal seated design for Process Air and Backwash Air application. All fasteners shall be set flush so as to offer the least resistance possible to the flow through the valve.

The shaft shall be stainless steel with Bronze or equivalent seal with self-lubricating bearings. Disc pins shall be stainless steel. Rings shall be bi-directional self-adjusting suitable for pressure or vacuum service. Valve shafts shall be a one-piece unit extending completely through the valve disc, or of the "stub shaft" type, which comprises two separate shafts inserted into the valve disc hubs.

All valve spindles and hand wheels shall be positioned to give good access for operational personnel. Valve of diameter 450 mm and above shall be provided with enclosed gear arrangement for ease of operation. The gear box shall be of worm and worm wheel design type, totally enclosed, grease filled and weather proof. The operation gear shall be such that they can be opened and closed by one man against an unbalanced head of 1.15 times the specified rating. Valve and gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 200 N. All hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.

Material of construction of valves shall comply with following requirement:

Component	**Material**
Body	SG Iron IS 1865 Gr. 500/7/GGG50 or 400/15/GGG40
Disc	SG Iron IS 1865 Gr. 500/7/GGG50 or 400/15/GGG40
Shaft	Stainless Steel; ASTM A 276 Gr. 431/420
Body Seat	Stainless Steel ASTM A 276 Gr.316/ CF8M
Bearing	Stainless Steel/Bronze backed Teflon
Disc seat	Stainless Steel ASTM A 276 Gr. Gr.316/ CF8M

Component	**Material**
Body seat	Stainless Steel; ASTM A 743 CF8M
Internal Fasteners	SS 316
External Fasteners	SS316

The disc shall be designed to withstand the maximum pressure differential across the valve in either direction of flow. The disc shall be contoured to ensure the lowest possible resistance to flow and shall be suitable for throttling operation.

Valves shall be capable of closing against the maximum flow that can occur in system. The shaft shall be designed to withstand the maximum torque that will be imposed by the operator. It shall be secured to the discs by tapered stainless steel cotter pins.

Valves shall be provided with position indicator to show the position of the disc, mounted on the driven shaft end.

Rigid adjustable stop mechanism shall be provided within the gear box or elsewhere on the valve to prevent movement of the disc beyond the fully open or closed position (i.e. set points).

8.2~~3~~6.3 Sluice Valve

(a) Sluice valve shall generally confirm to IS 14846.

(b) Sluice valves shall be of non-rising spindle type. The valve shall be furnished with a bushing arrangement for replacement of packing without leakage.

(c) Valves of 400 mm and above shall be provided with thrust bearing arrangement for ease of operation.

(d) Valves of diameter 400 mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 400 N.

(e) All valves, spindles and hand wheels shall be positioned to give good access for operational personnel.

(f) All the hand wheels shall be arranged to turn in a clockwise direction to close the valve. The direction of rotation for opening and closing of the valve shall be indicated on the hand wheels.

(g) The material of construction of valve shall be as follows:

Component	**Material**
Body / Dome / Bonnet	SG Iron IS 1865 Gr. 500/7/GGG50 or 400/15/GGG40
Wedge	SG Iron IS 1865 Gr. 500/7/GGG50 or 400/15/GGG40
Spindle	Stainless Steel; ASTM A 276 Gr. 431 S29 /420
Thrust collar & Wedge Nut	Bronze: IS:318 Gr LTB2
Seals	Food Grade EPDM
O-Rings	NBR
Seat / face Rings	Bronze IS 318 Gr. LTB 2/SS 316
Back Seat Bush	Bronze IS 318 Gr. LTB2/SS 316
Shoe and Channel lining	Bronze IS 318 Gr. LTB2/SS 316
Internal Fasteners	SS 316
External Fasteners	SS 316
Gear, Gear housing	Cast Steel ASTM A 216 Gr. WCB

8.26.4 Knife Gate Valves

Design & Construction Details:

The Knife gate valves shall be manufactured generally as per the latest AWWA C520-10 standards.

Other constructional features and details of components of the required valves are to be as under:

The valve body should be of ductile iron construction as specified. The valve should be provided with gate made of stainless steel of grade as specified and the gate should have beveled knife edge at the bottom to cut through and easily enter in the solids settled in the bottom and ensure positive shut-off / closure in sewage environment.

The Valve should be designed for sealing in uni-directional flow application.

The valve should be provided with replaceable type flexible sealing arrangement to offer drop tight shut off. The seals should be made of EPDM rubber and should be held in place by an easily removable type seal retainer ring. The seals should be mechanically retained in place in a machined groove on the face of seal retainer ring. The sealing system should be field replaceable at site.

The valve housing should have integral as cast tapered lugs provided for pushing the gate towards the flexible rubber seal only at the verge of closure with a view to avoid seal wear and achieve drop tight shut off. The surface of the gate coming in contact with the seal should be polished & buffed.

The bonneted valves shall have glandless design to avoid repeated tightening / replacement of gland packing. The stuffing “O” ring seal should be pressurized by thrust washer from both the sides and should be pressurized / tighten by thrust retainer nut.

The packings should be of graphited synthetic yarn to reduce the friction and offer higher life. Provision shall be made to enable tighten the gland packing by means of a pusher arrangement to minimize the leakage through the back of the valve. Replacement of gland packings should be possible in installed condition of the valve without there being line pressure.

The spindle should be double start / single threaded and non-rising type for compact & safe operation. Gate opening indicating arrangement should be provided to find out the extent of gate opening /closing. The operation of the valves shall be manual / motorized as specified elsewhere in the tender specification.

In case the valve is to be operated from a far then it shall be provided with joining couplings, extension spindle, spindle guides and mounting pedestal with suitable anchor bolts / anchor fasteners on the platform.

Materials of construction:

Component		**Material**
Body	:	Ductile iron (SG) IS 1865 Gr.400/12
Seal Retainer ring	:	Stainless steel to ASTM A-351 Grade CF8M
Inlet Seal / Rubber Seals / O rings	:	EPDM Rubber
Knife gate	:	Stainless Steel ASTM A 240 type 316
Spindle	:	Stainless Steel ASTM A 276 type 316
Assembly bolts, nuts and fastener	:	Stainless Steel ASTM A 276 type 316
Spindle nut	:	Gunmetal / Phosphor Bronze / Brass

Component	Material
Bracket / Adapter plate	: Mild Steel to IS: 2062 grade A, Epoxy Painted
Packing	: Graphited synthetic yarn

8.26.5 Slide Gate Valve

(a) Valve shall be of wafer type with elastomer body sealing arrangement for bi-directional shut-off. The valves shall be designed to allow gland repacking without relieving line pressure.

(b) Body shall be two-piece cast construction bolted together with a mid-flange.

(c) The elastomer body seal shall be held in body such that it is kept away from direct impingement of any particles in the flow medium.

(d) The gate shall be provided with a bevelled edge to facilitate positive closure of valve even with contaminated area.

(e) The body internals shall be countered such that settlement of particles in the media.

(f) Purge connection shall be provided optionally for these valves for cleaning the seating area.

(g) The material of construction of valve shall be as follows :

S. No.	Component	Material
(i)	Body	SG Iron IS 1865 Gr. 500/7/GGG50 or 400/15/GGG40
(ii)	Gate	Stainless Steel: BS:970 Gr. 316
(iii)	Stem	Stainless Steel: BS:970 Gr. 316
(iv)	Body seal	Stainless Steel: BS:970 Gr. 316
(v)	Hand wheel	Cast Iron: IS: 210 FG Gr. 260

8.26.6 Non Return Valve

(a) Type of Valve:

- For Raw Sewage, Clear water & Sludge Application: Only Swing type non return valve complying to IS 5312 is accepted for the individual delivery line & Common header of the pump. Swing door valves of size 600mm and above shall be of Multidoor type.

- For Process Air Application: Only Flap type non return valve is accepted for the individual delivery line & Common header of the Air Blower.

(b) The valves shall be suitable for mounting on a horizontal pipeline and flow direction shall be clearly embossed on the valve body. Hydraulic passages and doors shall be designed to avoid cavitation.

(c) Valves shall possess high speed closing characteristics and to be designed for minimum slam condition when closing.

(d) Valve of diameter greater than 450 mm shall be provided, in addition to others, supporting feet and jacking screws. Hinge pins / shaft shall preferably be square in section to ensure positive location of flaps and provide for secure fixing.

(e) Maximum pressure drop across the valve shall be 0.4 mwc. Maximum allowable leakage rate shall be 7cc/hr/mm diameter.

The material of construction of valve shall be as follows:

S. No	Component	Material
1.	Body and Doors/ with hinge and diaphragm	SG Iron IS 1865 Gr. 500/7/GGG50 or 400/15/GGG40
2.	Hinge pin/Shaft	Stainless Steel; ASTM A 276 Gr. 431 /420/410
3.	Seat / Face rings	Stainless Steel: ASTM A 743 CF8M / Integral Nickel-chromium overlay welding and micro finished
4.	Bearings Bush	Stainless Steel backed Teflon
5.	Shaft bearing	Bronze IS 318 Gr. LTB 2
6.	Internal & External Fasteners	SS 316

8.26.7 Telescopic Valves

The telescopic valve shall be a proprietary item of proven design manufactured in cast iron and adjustable to cater for variation in level.

The bell mouth height shall be controlled by a hand wheel operated from top of the chamber.

The bell mouth, pipe work, spindle and headstock shall be robustly constructed with adequate brackets of cast iron.

The bell mouth shall be connected by swept tees to a cast iron sludge outlet pipe of suitable diameter.

Component	**Material**
Bell Mouth	Cast Iron: IS:210 Gr. FG 260
Piping	Cast Iron: IS:210 Gr. FG 260
Spindle	Stainless Steel Gr. 304
Hand wheel	Cast Iron: IS:210 Gr. FG 260

8.26.8 Diaphragm Valves

Diaphragm valves shall be of the full-bore type to suit the maximum working pressure ratings required. Body ends shall be flanged and drilled to BS EN 1092-1.

Indicators shall be supplied where specified showing both OPEN and CLOSED positions shall be supplied and provisions made for initiating the operation of remote indicator lights in the fully OPEN and CLOSED positions.

Valves used for toxic or hazardous fluids shall be provided with an additional `O' ring seal of nitrite rubber or other approved material.

Diaphragms shall be composed of moulded reinforced, flexible material attached by studs to the compressor. Diaphragm materials shall, where required, be composed of corrosion resistant material.

8.26.9

~~8.26.10~~

~~**8.26.11**~~ **Isolating Cocks**

For isolation of small bore pipe work tapings for instrumentation equipment etc., and for individual component isolation, the cocks shall be stainless steel, 0.25 turn ball or plug valve with the operating handle arranged to indicate the open

and closed positions. Where specified, means shall be provided for securing the valve body to a front panel or near surface.

8.26.10 Pressure / Vacuum relief valves

Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurized in excess of a preset maximum allowable pressure. The valves shall be drops tight under no flow conditions.

Vacuum relief valves shall be capable of preventing the vacuum pressure to be developed in the system by allowing air entry. The valves shall be drops tight under no flow conditions.

The valve operation shall be achieved by the interaction of the inlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valve.

The pilot valve or relay system shall be actuated by a diaphragm connected to the inlet pressure on its underside and a constant pressure on its upper side derived either from weights or from a spring.

Body ends shall be flanged and drilled to BS EN 1092-1.

8.26.11 Adjustable Weir Plates

The adjustable weir plates shall be manufactured from 3 mm thick SS 304 Plates and to the approval of the Employers Representative.

Weir plates shall be complete with fixing nuts, bolts and washers and suitable for a total vertical adjustment of 100 mm through SS304 clamping plates. Fixings shall be designed for ease of accurately leveling the plates, securing the plates, and shall enable the plates to be adjusted during the life of the Works to accommodate differential settlement of the structure.

8.26.12 Eccentric Structure Valve

(a) Valve shall be eccentric structure or horseshoe type disc and body. The valve shall be used for sludge line and flow control.

(b) The valves shall be for a smooth flux of fluid and suitable for fluid contained sludge and impurities at the treatment plant.

(c) The material of construction of valve shall be as follows:

S. No.	Component	Material
(i)	Body	Ductile (SG) Iron: IS 1865 Gr.500/7
(ii)	Disc	Ductile (SG) Iron: IS 1865 Gr.500/7 with rubber lining
(iii)	Stem	Stainless Steel: BS:970 Gr 304
(iv)	Hand wheel	Cast Iron: IS:210 Gr FG 260

8.26.13 Air Valves

(a) The air valve must be of the type that incorporates a kinetic and an automatic air release valve in one unit. It should be able to release air (gases) and to admit air into the sewage line, when the line is emptied.

(b) The air valve must guarantee complete separation of liquid sewage from the sealing system of the air valve under all working conditions.

(c) The air valve must have arrangement for draining and flushing by external water.

(d) All sealing mechanism system parts of the air valve should be made of stainless steel-316.

(e) The body of the valve should be such as to minimise the accumulation of sewage deposit at the bottom of the coating or of cast iron. The valve mechanism must be such as to prevent opening of the air valve upon every slight pressure change in line. Air Valve shall be Epoxy powder coating shall be provided inside and outside.

(f) Each air valve must be supplied with a sluice vale for isolation for maintenance purpose.

Component	Material
Body/Top Cover	Ductile Iron Gr. GGG40/ GGG-50
Small orifice Plug	Leaded Tin Bronze IS 318 Gr. LTB 2/SS 316
Seat Ring	Leaded Tin Bronze IS 318 Gr. LTB 2/ SS 316
Float/Balls	SS AISI 304/ Polycarbonate
Cover Bolts	Austenitic alloy steel/SS 304
Gaskets & Seals	Food Grade EPDM

8.27 Domestic Water Pump sets

The Pump shall be of Centrifugal type, self-priming and monoblock type. All the necessary piping with union, bends and tees shall be provided. Suction and discharge isolation valves and non-return valves on the discharge side shall be forged steel. Piping shall be as per IS: 1239 heavy class.

8.28 Approved Vendor/Manufacturer/Make List-Mechanical Equipment

The naming of a manufacturer in this specification is not intended to eliminate competition or prohibit qualified manufacturers from offering equipment. Rather, the intent is to establish a standard of excellence for the material used, and to indicate a principle of operation desired.

	CONSOLIDATED Mechanical Equipment VENDOR LIST	
S.NO.	**ITEM DESCRIPTION**	**APPROVED VENDOR/ MANUFACTURER/ MAKE**
1	Ultrafiltartion	M/s. Veolia M/s. Hydronectics M/s. Premier Tech
2	UV Disinfection	M/s. Aqui Senso M/s. Premier Tech Aqua M/s. Aquaray M/s. Trojan
3	UV Feed Pump	M/s. Xylem M/s. Kishore Pumps M/s. Aqua
4	UF Backwash Pump	M/s. Xylem M/s. Kishore Pumps M/s. Aqua
5	Air Compressor	M/s Ingersoll Rand
		M/s Usha Compressor
		M/s Kirloskar Pneumatics
		M/s Atlas Copco
		M/S-Chicago Pneumatics
		M/S - Elgi Compressor

64	Cranes (EOT, Hoists, Jib cranes)	M/s Brady & Morris
		M/s Eddy Cranes
		M/s Safex Electromech
		M/S - Hercules Hoists Ltd.
		M/S - Avon Cranes
		M/S - Reva
		M/S - Wester
76	Exhaust Fans	M/s Alstom
		M/s Howden
		M/s Bajaj
		M/s Marathon
		M/s Crompton
		M/s Almonard
89	Chemical Dosing Pumps	M/s Milton Roy
		M/s Prominent
		M/s Heidelberg
		M/s Positive Metering Pumps
		M/s Swelore Engineering
		M/s SR Metering Pumps
9	Butterfly Valve	M/s Pentair
		M/s Fouress
		M/s VAG Valves
		M/s Hawle
		M/s Indian Valve Company
		M/s AVK Valves
		M/s KBL
10	Sluice Valve for Sewage Application	M/s VAG
		M/s KBL
		M/s AVK Valves
		M/s Jupiter Valves

		M/s Indian Valve Company
1115	Non-Return Valve for Sewage Application	M/s VAG
		M/s KBL
		M/s AVK Valves
		M/s Jupiter Valves
		M/s Indian Valve Company
		M/S - Nufibrotech,
		M/S - BSF
		M/S - Patel Air Flow
1248	UPVC & HDPE Pipes	M/s Jain Irrigation
		M/s Finolex
		M/s Duraline
		M/s Manikya Palstichem
		M/s Pennwalt Agro
		M/s - Astral
		M/s - Ashirwad
		M/s - Prince
		M/s - Supreme
1349	Basket Type Strainer/Self Cleaning online Filters for UF system	Amiad filter
		STF Filters
		Filter Concept

All the equipment, to be supplied under this contract has to be from experienced manufacturer. The equipment of only those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered.

Note-1: In order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service, like items of equipment provided hereunder shall be the end products of one (1) manufacturer.

Note-2: In the event that the contractor wishes to propose alternate makes for the equipment mentioned above, he shall submit the following during detailed engineering:

1) Demonstrate that the proposed makes are “equivalent ” to the approved makes. The contractor shall ensure that alternate makes proposed, shall comply completely to the tender specifications, before the same is submitted for approval.
2) Submit ISO certificates for the OEM.
3) Submit quality certificates that the equipment adheres to, as required under this contract.
4) Submit product brochures for the proposed equipment, with information on spares availability and service setup in employer’s country.
5) Manufacturer involved in manufacture of specified proposed equipment for at least 10 years before bid date
6) End user performance certificates for minimum 5 successful individual installations of similar size or capacity as per this contract with the proposed equipment and model no, commissioned and satisfactorily operating for at least 5 years before bid date.
7) Manufacturer to provide full contact information for each reference as part of submission.

And the above qualities and requirements shall be demonstrated and evidenced by inspection of manufacturing units and successfully installed plants (at the End users plant/premises) for the equipment’s desired and successful operation and certification by the Employer/Engineer (BWSSB)/Representative.

The Employer shall reserve the right to accept or reject the Bidder proposed makes of Equipment.

8.29Warranty

- Comply with the requirements of each type of Equipment and specification mentioned elsewhere in this document.
- Warrant all components to be free of defects in materials or workmanship for 12 months from date of Taking Over Certificate.
- Individual warranties by component manufacturer in lieu of single source responsibility by the main Equipment manufacturer shall not be acceptable.
- Items which fail during the warranty period, excluding expendable items, shall be replaced without cost to the Employer.
- Provide manufacturer’s guarantee and warranty certificates prior to equipment start-up.

8.30 Pipelines, Pipe work and Fittings

8.30.1 Applicable codes

The following codes and standards unless specified herein shall be referred to, or equivalent to the approval of Engineer. All the Pipe material shall be as per IS/BS/JIS standards.

8.30.2 Materials

IS : 210	Specification for grey iron casting
IS : 290	Specification for coal tar black paint
IS : 456	Code of practice for plain and reinforced concrete
IS : 458	Specification for pre-cast concrete pipes (with and without reinforcement)
IS : 516	Method of test for strength of concrete
IS : 638	Specification for sheet rubber jointing and rubber insertion jointing
IS : 783	Code of practice for laying of concrete pipes
IS : 816	Code of practice for use of metal arc welding for general construction in mild steel
IS : 1367	Technical supply conditions for threaded steel fasteners
IS : 1387	General requirements for the supply of metallurgical materials
IS : 1500	Method for Brinell hardness test for metallic materials
IS : 1536	Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage
IS : 1537	Specification for vertically cast-iron pressure pipes for water, gas and sewage
IS : 1538	Specification for cast iron fittings for pressure pipes for water, gas and sewage
IS : 1916	Specification for steel cylinder pipes with concrete lining and coating
IS : 2078	Method for tensile testing of grey cast iron
IS : 3597	Method of tests for concrete pipes
IS : 3658	Code of practice for liquid penetrant flow detection
IS : 5382	Specification for rubber sealing rings for gas mains, water

:		mains and sewers
IS	5504	Specification for spiral welded pipes
:		
IS	6587	Specification for spun hemp yarn
:		
IS	7322	Specification for specials for steel cylinder reinforced
:		concrete pipes

8.30.3 Code of Practice

IS	783	Code of practice for laying of concrete pipes
:		
IS	3114	Code of practice for laying of cast iron pipes
:		
IS	3764	Excavation work - Code of Safety
:		
IS	4127	Code of practice for laying of glazed stoneware pipes
:		
IS	5822	Code of practice for laying of electrically welded steel pipes
:		for water supply.
IS	6530	Code of practice for laying of asbestos cement pressure
:		pipes.

8.30.4 Materials for Pipelines

Each pipeline shall be constructed in a material compatible with the fluid conveyed through that pipeline, i.e. the materials used in the pipes which are or can be in contact with the untreated or treated sewage, shall not contain any matter which could impart taste or odor or toxicity or otherwise be harmful to health or adversely affect the sewage conveyed. Nor shall any pipe be adversely affected by the fluid being conveyed through that pipe.

Pipe work and valve materials for the following duties shall be as follows or equivalent to the approval of the Engineer:

TABLE 8.1 ..... PIPE WORK AND VALVE MATERIALS

Application / Location	Material
~~Chlorine:~~ ~~Drum connections~~	~~Cadmium plated 70/30 copper nickel CN 107, BS 2871: Part 1~~
~~Chlorine gas or liquid~~	~~flanged or welded carbon steel, CAF flanged joints~~

Application / Location	Material
Chlorine gas lines below atmospheric pressure	Polyvinylidene fluoride (PVDF) with solvent welded or flanged joints/ Class E UPVC in concrete covered ducts outside building.
Chlorine solution	Inside building and in exposed areas, rubber lined carbon steel Valves shall be globe type with forged steel bodies, monel spindles, stainless steel seats and PTFE gland packing or carbon steel, monel plug, PTFE sleeved plug
Polyelectrolyte & Alum dosing line	UPVC/HDPE/HDPE (High density polyethylene) PVC with 10 Kgf/cm2
Sewage Raw Sewage, Process sewage, dirty waste water, supernatant and treated Sewage/Effluent, Process sludge	Mild steel with mortar lining/Guniting (Beyond 1200mm diameter of pipe) or Ductile Iron (Up to 1200mm) K9 class.
Service water	UPVC/HDPE (below 100 mm), ductile iron (100 mm and above).
Process Air	Blower individual delivery and common header shall be Stainless steel AISI 304 (Schedule 10). After Common header, Aeration tank top of platform and piping entering aeration tank and individual drop legs of diffusers shall be of Stainless steel AISI 316 (Schedule 10) for exposed or buried service and for submerged service.
Digester Gas	SS304 Schedule 10 for Header and distribution pipe at top of digester, interconnection pipes in the plant shall be to SS304 sch10

8.40.5 Ductile Iron Pipes and Fittings

8.40.5.1 Pipes and Fittings

(a) General

Ductile iron pressure pipes and fittings (Class K9) shall comply with IS 8329 and IS 9523. All fittings shall be socketed unless specified otherwise.

(b) Materials

The materials used in the manufacture pipes and fittings shall comply with IS 8329 and IS 9523.

(c) Tests

Tests on pipes and fittings shall be carried out in accordance with IS 8329 and IS 9523. The test method shall be submitted for approval of Engineer.

The Engineer shall be permitted free access to the place of manufacture for the purpose of examining, inspection and witnessing the testing of pipes and fittings.

8.40.5.2 Joints

(a) Spigot and Socket Joints

These shall have sockets which are integral with the pipe and incorporate an elastomeric rubber ring gasket conforming to IS: 5382 (Latest edition/revision with amendments, if any).

(b) Flanged Joints

These shall comply with dimensions and drilling details shall be to BS EN 1092-1/BS: 4504 Table10/11 and16/11. All flanged joints between steel and ductile iron pipe work shall be electrically isolated joints. These shall have isolation gaskets between the flanges, isolation sleeves around all bolts and isolation washers under all bolt heads and nuts. All materials shall be supplied by a specialist manufacturer and be to the approval of the Engineer.

8.40.5.3 Linings

Ductile iron pipes and fittings shall have a cement mortar lining, in accordance with IS 11906 or ISO 4179.

Pipe linings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Engineer. The Contractor may use specialist mortars, mortar additives or curing agents only with the approval of the Engineer.

Certain sections are amplified as follows:

No additives shall be used without the written approval of the Engineer, and shall be used strictly in accordance with the manufacturer’s recommendations.

The minimum thickness of the lining at one point shall not be less than 4 mm or as per IS 8329.

8.40.5.4 Coating

(a) General

Ductile iron pipes and fittings shall be zinc coated with bitumen over coating, all in accordance with the following Specifications. Pipe coatings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Engineer.

(b) Zinc Coating

Zinc coating shall comply with ISO 8179 and shall be applied as a spray coating. The mass of sprayed metal shall not be less than 130 g/m^2 as described in Clause 5.2 of ISO 8179.

(c) Bitumen Coating

Bitumen coating shall be of normal thickness 0.07 mm unless otherwise specified. It shall be a cold applied compound complying with the requirements of BS 3416 Type II, suitable for tropical climates, factory applied in accordance with the manufacturer's instructions.

Damaged areas of coating shall be repainted on site after removing any remaining loose coating and wire brushing any rusted areas of pipe.

(d) Polythene Sleeving

Where polythene sleeving is specified (generally for all buried DI pipes need sleeve covering) to be applied in addition to bitumen coating it shall comply with ISO 8180. Site applied sleeving shall be stored under cover, out of direct sunlight, and its exposure to sunlight shall be kept to a minimum. Pipes having a factory applied sleeving must be stored in the same conditions.

8.30 Reinforced Cement Concrete Pipes

8.41.1 Design

Design of RCC pipes including reinforcement details and the ends of pipes shall be in accordance with the relevant clauses of IS: 458.

Manufacturing

General

The method of manufacture shall be such that the form and the dimensions of the finished pipes are accurate within the limits specified in relevant clause of IS: 458. The surfaces and edges of the pipes shall be well defined and true, and their ends shall be square with the longitudinal axis. The ends of the pipes shall be further reinforced by an extra ring of reinforcement to avoid breakage during transportation.

The RCC pipes and collars/rubber rings shall be systematically checked for any manufacturing defects by experienced supervisors so as to maintain a high standard of quality.

The Engineer shall at all reasonable times have free access to the place where the pipes and collars/rubber rings are manufactured for the purpose of examining and testing the pipes and collars/ rubber rings and of witnessing the test and manufacturing.

All tests specified either in this Employer's Requirements or in the relevant Indian standards shall be performed by the supplier/contractor at his own cost and in presence of the Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes of that lot. The decision of the Engineer in this matter shall be final and binding on Contractor and not subject to any arbitration or appeal.

8.41.2 Materials

For all materials Factory's test result, and written guarantee document with necessary analysis data shall be submitted to obtain the approval of the Engineer before carrying to sites.

(a) Cement

Cement shall be used for the manufacture of sulphate resistant cement RCC pipes and collars shall conform to relevant IS codes. The use of pozzolana as an admixture to Portland cement shall not be permitted.

(b) Aggregates

Aggregates used for the manufacture of RCC pipes and collars shall conform to IS: 383. The maximum size of aggregate should not exceed one third the thickness of the pipe or 20mm, whichever is smaller.

(c) Mixing and Curing Water

Water shall be clean, Colour less and free from objectionable quantities of organic matter, alkali, acid, salts, or other impurities that might reduce the strength, durability or other desirable qualities of concrete and mortar. Contractor shall submit water quality report before using it.

(d) Reinforcement

Reinforcement used for the manufacture of the RCC pipes and collars shall be mild steel Grade I or medium tensile steel bars conforming to IS: 432 (Part-1) or hard-drawn steel wire conforming to IS: 432 (part-2). Reinforcement cages for pipes and collars shall be as per relevant requirement of IS:458.

(e) Concrete

Concrete used for the manufacture of RCC pipes and collars shall conform to IS: 456. The minimum cement content and minimum compressive strength of concrete shall be as per relevant requirements of IS: 458. Compressive strength tests shall be conducted on 15 cm cubes in accordance with the relevant requirements of IS: 456 and IS: 516.

(f) Curing

Pipes manufactured in compliance with IS: 458 shall be either water cured or steam cured in accordance with the relevant requirements of IS: 458.

(g) Dimensions

The internal diameter, wall thickness and length of barrel and collar of pipes, reinforcement (longitudinal and spiral), type of ends and minimum clear cover to reinforcement and strength test requirements shall be as per the relevant clauses / tables of IS:458 for different classes of pipes.

The tolerances regarding overall length, internal diameter of pipes or sockets and barrel wall thickness shall be as per relevant clause of IS: 458.

(h) Workmanship and Finish

Pipes shall be straight and free from cracks. The ends of the pipes shall be square with their longitudinal axis so that when placed in a straight line in the trench no opening between ends in contact shall exceed 3 mm in pipes upto 600mm diameter (inclusive), and 6 mm in pipes larger than 600 mm diameter.

The outside and inside surfaces of the pipes shall be smooth, dense and hard, and shall not be coated with cement wash or other preparation unless otherwise agreed to between the Engineer and the manufacturer or supplier.

The pipes shall be free from defects resulting from imperfect grading of the aggregate, mixing or moulding.

The pipes shall be free from local dents or bulges greater than 3 mm in depth and extending over a length in any direction greater than twice the thickness of barrel.

The deviation from straight in any pipe throughout its effective length, tested by means of rigid straight edge parallel to the longitudinal axis of the pipe shall not exceed, for all diameters 3 mm for every meter run.

(i) Testing

All pipes for testing purposes shall be selected at random from the stock of the manufacturer and shall be such as would not otherwise be rejected under the criteria of tolerances as mentioned in IS 458. Engineer reserve the right to attend all testing.

During manufacture, tests on concrete shall be carried out as per IS: 456. The manufacturer shall supply, when required to do so by the Engineer the results of compressive tests of concrete cubes and split tensile tests of concrete cylinders made from the concrete used for the pipes. The manufacturer shall supply cylinders or cubes for test purposes required by the Engineer and such cylinders or cubes shall withstand the tests prescribed as per IS 458. Every pressure pipe shall be tested by the manufacturer for the hydrostatic test pressure. For non-pressure pipes, 2 percent of the pipes shall be tested for hydrostatic test pressure.

The specimen of pipes for the following tests shall be selected in accordance with relevant clause of IS: 458 and tests in accordance with the methods described in IS: 3597.

i) Hydrostatic test
ii) Three edge bearing test
iii) Absorption test
iv) Visual Examination

(j) Sampling and Inspection

In any consignment, all the pipes of same class and size and manufactured under similar conditions of production shall be grouped together to constitute a lot. The conformity of a lot to the requirements of this Employer's Requirements shall be ascertained on the basis of tests on pipes selected from it.

The number of pipes to be selected from the lot for testing shall be in accordance with Table 15 of IS: 458.

Pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every pipe be selected till the requisite number is obtained, or being the integral part of N/n where N is the lot size and n is the sample size.

All pipes selected shall be inspected by Engineer for dimensional requirements, finish and deviation from straight. A pipe failing to satisfy one or more of these requirements shall be considered as defective.

The number of pipes to be tested shall be in accordance with column 4 of Table 15 of IS:458. These pipes shall be selected from pipes that have satisfied the requirements mentioned in the above clause.

A lot shall be considered as conforming to the requirements of IS:458 if the following conditions are satisfied.

The number of defective pipes shall not be more than the permissible number given in column 3 of Table 15 of IS: 458.

All the pipes tested for various tests shall satisfy corresponding requirements of the tests.

In case the number of pipes not satisfying requirements of any one or more tests, one or two further samples of same size shall be selected and tested for the test or tests in which the failure has occurred. All these pipes shall satisfy the corresponding requirements of the test.

All result of tested data must be prepared by contractor at site so that the Engineer shall make decision of "fail or pass" at once. All cost for the test shall be borne by the Contractor.

(k) Marking

The following information shall be clearly marked on each pipe:

a) Internal and External diameter and length of pipe
b) Class of pipe
c) Date of manufacture and
d) Name of manufacturer or his registered trade-mark or both.

8.30 Jointing

General

Jointing of RCC pipes shall be done as per the requirements of following Employer's Requirements and as per the relevant IS standard. After jointing, extraneous material, if any, shall be removed from the inside of the pipe and the newly made joints shall be thoroughly cured. In case, rubber sealing rings are used for jointing, these shall conform to IS: 5382. The pipe joint work must be done neatly and keep even slope and level for pipe laying works.

(a) Spigot and Socket joint (Rigid)

The spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. The opening of the joint shall be filled with stiff mixture of cement mortar which shall be rammed with caulking tool. This joint is used for low pressure pipe line.

(b) Collar Joint (Rigid)

After laying the RCC pipes at proper alignment and gradient their abutting faces shall be coated with hot bitumen in liquid condition by means of a brush. The wedge-shaped groove in the end of the pipe shall then be filled with a tarred gasket in one length for each joint. The collar shall then be slipped over the end of the pipe and the next pipe butted well against the tarred gasket by suitable appliances approved by the Engineer so as to thoroughly compress the tarred gasket into the grooves, care being taken that the concentricity of the pipes and levels are not disturbed during this operation.

The collar shall then be place symmetrically over the end of the two pipes and the space between the inside of the collar and the outside of the pipe filled with a mixture of cement and sand to withstand any stress and prevent any water leakage, tempered with just sufficient water to have a consistency of the semi-dry conditions, well packed and thoroughly rammed with caulking tools. The joints shall be finished off with a fillet sloping at 45^0 to the side of the pipe. The finished joints shall be protected and cured thoroughly as directed by the Engineer. Any plastic solution or cement mortar that may have been squeezed into the inside of the pipe shall be removed so as to leave the inside of the pipe perfectly clean.

(c) Flush Joint (Internal)

This joint shall be generally used for culvert pipes of 900 mm diameter and over. The ends of the pipes are specially shaped to form a self-centering joint with an internal jointing space 13 mm wide. The finished joint is flush with both inside and outside with the pipe wall. The jointing space is filled with cement mortar mixed sufficiently dry to remain in position when forced with a trowel or rammer.

(d) Flush Joint (External)

This joint is suitable for pipes which are too small for jointing from inside. This joint is composed of specially shaped pipe ends. Each end shall be butted against each other and adjusted in correct position. The jointing space shall then be filled with cement mortar sufficiently dry and finished off flush. Great care shall be taken to ensure that the projecting ends are not damaged as no repairs can be readily affected from inside the pipe.

(e) Spigot and Socket (Semi-flexible)

This joint is composed of specially shaped spigot and socket ends on the RCC pipes. A rubber ring shall be lubricated and then placed on the spigot which is forced into the socket of the pipe previously laid. This compresses the rubber ring as it rolls into the annular space formed between the two surfaces of the spigot and socket, stiff mixture of cement and mortar shall then be filled into the remaining annular space with a caulking tool.

(f) Collar Joint (Semi-Flexible)

This joint is made up of a loose collar which covers two specially shaped pipe ends. Each end shall be fitted with a rubber ring which when compressed between the spigot and collar, seals the joint. Stiff mixture of cement mortar shall then be filled to withstand stress and prevent any water leakage, into the remaining annular space and rammed with a caulking tool.

(g) Spigot and Socket Joint (Flexible)

The RCC pipe with the rubber ring accurately positioned on the spigot shall be pushed well home into the socket of the previously laid pipe by means of uniformly applied pressure with the aid of a jack or similar appliance. The RCC pipes shall be of spigot and socket type and rubber rings shall be used, and the manufacturer’s instructions shall be deemed to form a part of these Employer’s Requirements. The rubber rings shall be lubricated before making the joint and

the lubricant shall be soft soap water or an approved lubricant supplied by the manufacturer.

(h) Cleaning of Pipes

As soon as a stretch of RCC pipes has been laid complete from manhole to manhole or for a stretch as directed by the Engineer, Contractor shall run through the pipes both backwards and forwards a double disc or solid or closed cylinder 75 mm less in diameter than the internal diameter of pipes. The open end of an incomplete stretch of pipe line shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipe lines, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

It shall also be ascertained by contractor that each stretch from manhole to manhole or the stretch as directed by Engineer is absolutely clear and without any obstruction by means of visual examination of the interior of the pipe line suitably enlightened by projected sunlight or otherwise.

(i) Testing at work site

After laying and jointing of RCC pipes is completed the pipe line shall be tested at work site as per the following Employer’s Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be contractor's responsibility and shall be rectified by him to full satisfaction of the Engineer. Water used for the test shall be removed from pipes and not released to the excavated trenches.

After the joints have thoroughly set and have been checked by the Engineer and before back filling the trenches, the entire section of the sewer or storm water drain shall be proved by the contractor to be water tight by filling in pipes with water to the level of 1.50m above the top of the highest pipe in the stretch and heading the water up for a period of one hour. The apparatus used for the purpose of testing shall be approved by the Engineer. Contractor if required by the Engineer shall dewater the excavated pit and keep it dry during the period of testing. The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular 10 minutes intervals and noting the quantity required to maintain the original water level. For the approval of this

test the average quantity added should not exceed 1 liter/ hour/100 linear metres/10 mm of nominal internal diameter. Any leakage including excessive sweating which causes a drop in the test water level will be visible and the defective part of the work should be removed and made good.

In case of pressure pipeline, the completed stretch of pipeline shall be tested for site test pressure. The site test pressure should not be less than the maximum operating pressure plus the calculated surge pressure, but in no case should it exceed the hydrostatic test pressure as specified in IS: 458.

All of results of test and inspection data must be prepared by contractor at site so that the Engineer shall make decision of “fail or pass” at once. All cost for the inspection shall be borne by the Contractor.

8.30Steel Cylinder Pipes and Specials

8.43.1 Design

In general the design of steel cylinder pipes with concrete lining and coating shall conform to clause 8 of IS 1916. In addition to above, in case of buried pipe line, the pipe shall also be designed for the Earth load, and traffic load.

8.43.2 Manufacturing

(a) General

Steel cylinder pipes and specials with concrete lining and coating shall be systematically checked for any manufacturing defects by experienced supervisors and a very high standard of quality shall be maintained. The pipes and specials shall be inspected by Engineer at site and factory, and defects noticed, if any, such as protrusions, grooves, dents, notches, etc. shall be rectified, if agreed to by the Engineer. Care shall be taken that the resulting wall thickness does not become less than the minimum specified. If the wall thickness becomes less than the minimum specified, as per Table 1 of IS: 1916, the damaged portion should be cut out as cylinder and replaced by an undamaged piece of pipe at no extra cost to the Engineer.

The Engineer shall at all reasonable times have free access to the place where the pipes and specials are manufactured for the purpose of examining, inspection and testing the pipes and specials and for witnessing the test and manufacturing.

All tests specified either in this Employer's Requirement or in the relevant Indian Standards shall be performed by Supplier/Contractor at his own cost and in presence of the Engineer, if desired. For this sufficient notice before testing of the pipes and specials shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes and specials of that lot. The decision of the Engineer in this matter shall be final and binding on the Contractor.

(b) Materials

All material shall conform to Clause 7 of IS 1916.

(c) Manufacturing Process

Steel cylinder pipes with concrete lining and coating shall be manufactured as per Clause No.9 of IS: 1916 and specials shall be manufactured as per Clause 7 of IS:7322. In case of spiral welded pipes, they shall be manufactured as per Clause 3 of IS: 5504. Internal lining shall be upto the full length of the pipes and specials. However, external coating shall be done leaving about 100 mm length of the pipes and specials from their ends. The internal lining and external coating to pipes and specials shall be done at factory. Before lining/coating by concrete/mortar the surface of pipes and specials shall be thoroughly cleaned. In the event that loose mill scale, tuberculation, or an accumulation of dirt, debris, oil or grease is present, it shall be removed from the surface by hand, by machine or both and given a coating of neat cement slurry.

(d) Dimensions

The clear cover to the reinforcement whether steel cylinder or cage shall be not less than 9 mm for lining of pipe/special and 12 mm for coating of the pipe/special.

The permissible tolerance for diameter and length of pipe shall be as per Clause 4 of IS: 1916, whereas for diameter, arm length and angular deviation of specials the tolerance limit shall be as per Clause 6 of IS: 7322.

(e) Workmanship and Finish

Workmanship and finish of pipe shall conform to Clause 4 of IS: 1916.

(f) Testing

Each steel cylinder shall be subjected before lining/coating to a hydrostatic test under a water pressure equivalent to the test pressure in accordance with Clause 10 of IS:1916 and relevant provisions of IS:3597, provided that the whole of the area of the calculated reinforcement is used in the steel cylinder. In the case of pipes where a part of the principal reinforcement is provided in the cage, the steel cylinder shall be subjected to proportionately less hydrostatic test pressure.

Manufacturer's standard specials shall be hydrostatically tested before lining/coating. Where feasible, other specials shall be hydrostatically tested (before lining/coating) at factory. However, when this is not practicable, at the discretion of the Engineer, the unlined specials shall be tested by penetration test as per IS: 3658 or other approved means.

All of results of test and inspection data must be prepared by contractor at site so that the Engineer shall make decision of “fail or pass” at once. All cost for the inspection shall be borne by the Contractor

(g) Penetration Test

A suitable liquid penetrant (kerosene oil/Dye) is applied to the surface of the portion under examination and is permitted to remain there for sufficient time to allow the liquid to penetrate into any defects open at the surface. After the penetrate time, the excess penetrant which remains on the surface, is removed. Then a light colored powder absorbent called a developer is applied to the surface. This developer acts as a blotter and draws out a portion of the penetrant which had previously seeped into the surface openings. As the penetrant is drawn out it diffuses into the coating of the developer, forming indication of the surface discontinuities or flaws.

(h) Marking

The following information shall be clearly marked on each pipe and special:

i) Internal diameter, external diameter and thickness
ii) Class of pipe and special with its serial number
iii) Date of manufacture and
iv) Name of manufacturer or his registered trademark or both

(i) Jointing

Jointing of steel cylinder pipes and specials with concrete lining and coating be done as per the relevant IS. After jointing, extraneous material if any, shall be removed from the inside of the pipe and special. The welding of joints for pipes and specials at work sites shall comply with 816. Electrodes used for welding shall comply with IS: 814.

i. Butt Welded Joint

After pipes and specials are laid in the trench, the faces of pipes/specials shall first be tack-welded alternately at one or more diametrically opposite pairs of points. After completing tack welding, full welding shall be carried out in suitable runs following a sequence of welding portions of segments diametrically opposite. After jointing the exposed surface of the steel cylinder of pipes and specials shall be coated with M20 cement concrete of sufficient thickness so as to make it flush with the adjoining both inner and outer faces of pipes and specials. The gap in the internal lining at the joints shall be filled with cement mortar (1:2) for pipes and specials larger than 600 mm diameter. The lining/coating shall be done after the field test in the section has been successfully completed.

ii. Lap Welded Joint with Slip-in-ends

In the case of pipes with plain or slip-in-ends, swaged end of the steel cylinder may be formed by heating one of its ends and expanding it or rolling it out to the required shape. The minimum depth and maximum clearance between the swaged end and the plain end of pipes for field welding shall be provided as directed by the Engineer. Lap welding shall be done from the external face at the junction of pipe and socket. After jointing the exposed surface of the steel cylinder of pipes and specials shall be coated with M20 cement concrete of sufficient thickness so as to make it flush with the adjoining both inner and outer faces of pipes and specials. The gap in the internal lining at the joints shall be filled with cement mortar (1:2) for pipes and specials larger than 600 mm diameter. The lining/coating shall be done after the field test in the section has been successfully completed.

iii. Flanged Joints

The flanges for steel cylinder pipes and specials shall be as per BS EN 1092-1/BS4504. Flanges shall be provided at the end of pipes or specials where valves, blank flanges etc. have to be introduced or flanged joints for the pipes are specified. The flanges shall have necessary bolt holes drilled. It might be necessary for contractor to follow the instructions and specifications given by the valve manufacturer. All bolts, nuts and packing material required for flanged

joints shall be provided by the Contractor. Bolts and nuts shall conform to IS: 1367 whereas rubber gasket of required thickness shall conform to IS: 638.

The bolts shall be evenly tightened in comply with relevant BS standard. Random inspection shall be carried out by jointly the Engineer and the contractor.

(j) Cleaning of pipes and specials

Contractor shall ascertain that each stretch of pipeline is absolutely clear and without any obstruction by means of visual examination of the interior of pipeline suitably lighted by projected sunlight or otherwise. The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipeline, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

(k) Testing at work site

After laying and jointing of steel cylinder pipes and specials with concrete lining and coating is completed the pipeline shall be tested at work site as per the following Employer’s Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by Contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be Contractor’s responsibility and shall be rectified by him to the full satisfaction of the Engineer. Water used for test shall be removed from pipes and not released to the excavated trenches.

Each section of the pipe line shall be slowly filled with clean water and all air shall be expelled from the pipeline. The pressure in the pipeline should then be raised and maintained by means of pump to the test pressure. The test pressure should not be less than 1 1/2 times the working pressure at the lowest point or the static head pressure, whichever is higher. Under the test pressure no leak or sweating shall be visible at the welded joints. The duration of test shall be not less than 24 hours. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be rewelded. Any cracked or defective pipes and specials in consequences of this pressure test shall be removed and replaced by sound material by Contractor and the test shall be repeated to the satisfaction of the Engineer.

Proper arrangement of thrust blocks shall be provided during pressure testing or pipe laying works.

8.30Steel Pipe work

Pipe/fitting material and dimensional standard shall conform to following:

Size mm (NB)	Material Specification (Steel)	Dimensional Standard
Pipes upto 150 mm	1239 PT, ERW, Black PT-1 HVY	1239 ERW
200 to 2400	2062	3589 – ERW 3589 for dimensions and minimum thickness. Pipe thickness shall be as per 2825
Elbows upto 25	ASTM–A 105	ANSI B 16.11 3000 # S.W.
40 to 150	ASTM-A 234 GR WPB	ANSI B 16.9
200 & above (meters)	2062	LR. BE. Sch 40 ANSI B 31.1
Coupling upto 25	ASTM-A 105	ANSI B 16.11 3000 # S.W.
Tees 40 to 200	ASTM – A 234 GR WPB	ANSI B 16.9 BE, Sch 40
Above 200	IS 2062	IS 2825 (min. Pipe thickness)
Reducers upto 25	ASTM-A 105	ANSI B 16.11 3000 S.W.
40 to 200	ASTM-A 234 GR WPB	ANSI B 16.9 BE, Sch 40
Above 200	2062	IS 2825 (min. Thickness for larger pipes)
Flanges	2062	BS EN 1092-1
Bolts, Anchor Bolts and all nuts	SS316	1364
Gaskets All	638 (rubber) reinforced	3 mm thickness

Facilities shall be provided for draining the pipe system and releasing air.

The pipe work layout within pump stations shall have the approval of the pump manufacturer. Fluid velocities in suction pipe work leading to pumps shall not exceed 1.5 m/s. Fluid velocities in delivery pipe work leading from pumps shall not exceed 2.0 m/s.

The whole of the jointing work and materials necessary to fix and connect the pipes, including adequate and efficient pipe support shall be included in the Contract. The Contractor shall be responsible for ensuring that the internal surface of all pipe work is thoroughly cleaned before and during erection and before commissioning.

Cleaning shall include removal of all dirt, rust, scale and welding slag due to Site welding. Before dispatch from the manufacturer's works, the ends of the pipes, branch pipes, etc., shall be suitably capped and covered to prevent any accumulation of dirt or damage. This protection shall not be removed until immediately prior to connecting adjacent pipes, valves or pumps. All small bore pipes shall be blown through with compressed air before connection is made to instruments and other equipment. No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Employer.

Hydrostatic shop test for pipes and fittings shall be as per code/standard requirement. After erection at site, complete pipes and fittings shall be hydrostatically tested for a pressure of 1.5 times operating pressure.

Flanges, if fabricated in segments shall be fully radiographed and stress relieved. If fabricated out of billets/bars by cold rolling, welded flanges shall be radiographed and normalized.

Protection for pipes laid underground shall be by coating and wrapping system giving a final coat thickness of 4.5 mm may be employed. Such protection shall comprise 1.5 mm of coal tar primer application on a thoroughly cleaned surface, to be followed with fiber glass wraps set in coal tar enamel coats conforming to American Water Works Association Specification C/203/57 for a total thickness of 3 mm. Such lining shall meet a spark test to be approved with a holiday detector of 10000 Volts.

The Contractor shall indicate on his detailed drawings what thrust blocks are required to anchor pipe work supplied by him. Particular care shall be taken to ensure that pipe work thrusts are, as far as possible, not transmitted to machinery or other associated apparatus.

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawings and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the prior approval of the Employer.

Buried pipes shall in addition be designed to withstand external loading exerted by soil, water, and live loads as relevant. The external ground water shall be taken at ground level for design purposes. Saddle type/bracket type support wherever required shall be designed and supplied for the above ground pipe lines.

All pipe joints shall be of the butt welded type. End preparations and fabrication requirements shall generally conform to I.S. 2825. Flanges, if fabricated in segments, shall be fully radiographed and stress relieved.
Laying of welded steel pipes shall meet the requirements of I.S. 5822.

(a) Welded Joints for Steel Pipes

Welding of joints in steel pipes shall be carried out manually by the metal arc welding process complying with AWWA Standard C206.

Before starting the welding of pipe joints in the Works the Contractor shall submit for the Engineer's approval details of the plant, methods and materials he proposes to use, including make and size of electrodes, number of runs, current strength and arrangements for air testing of individual joints.

Welding shall only be carried out by welders approved by the Engineer and each welder shall identify his work by means of a stenciled mark.

Welded joints other than for closing lengths shall be of the spherical spigot and socket type. For pipes of 675 mm diameter and smaller the pipe joint shall be welded externally. For pipes larger than 675 mm the pipe shall be welded internally and a sealing weld made externally.

All parts to be welded shall have loose scale, slag, rust, paint and other foreign matter removed by means of a wire brush and shall be left clean and dry. All scale and slag shall be removed from each weld run when it is completed. Pipes manufactured with longitudinal or spiral welds shall be lined up before jointing so that these welds are at least 15^{o} apart around the joint circumference.

For pipes larger than 900 mm diameter a triple run convex fillet weld shall be used. For pipes of 900 mm diameter or less a double run convex fillet weld shall be used. The minimum leg length of the fillet as deposited is to be equal to the full thickness of the pipe wall. The actual throat depth shall not be greater than 9/10th and not less than 7/10th of the minimum leg lengths as deposited. The depositing of the weld metal shall be carried out in such a manner as to ensure that all the welds have adequate root fusion and are of good clean metal free from cracks, gas holes, slag inclusions and all other impurities. The surface of the

weld shall have an even contour with regular finish and shall indicate proper fusion with the parent metal. All slag shall be thoroughly removed after depositing each run of welding by light hammering with a chipping hammer followed by wire brushing. Any welds showing cracks or other cavities or in which the weld metal tends to overlap on to the parent metal without proper fusion or containing any other defects whatsoever shall be cut out and rewelded to the satisfaction of the Engineer at the Contractor's expense.

At closing lengths where two plain ended pipes are to be joined by a welded joint the gap between the two ends shall not exceed 75 mm. An external steel sleeve collar, of a thickness not less than that of the pipe itself and approximately 300 mm in length shall be placed centrally over the two ends to be jointed and the end of each pipe shall then be fillet welded to the sleeve collar in accordance with the above procedure.

No weld or adjacent parts of the pipe shall be painted prior to inspection by the Engineer.

(b) Welder Performance Test

The Contractor shall submit for the Engineer's approval the names of persons whom he proposes to employ as welders with evidence that, as a minimum preliminary qualification, they have passed the qualifying tests prescribed in Clause 11 of BS 2633 and possessed certificates from an independent testing authority. The Engineer may further require any such person to perform satisfactory test welds under Site conditions and on pipes similar to those for use in the Works, before approving his employment as a welder. The Contractor shall maintain an up-to-date list of welders approved by the Engineer and if ordered by the Engineer he shall remove from the approved list any welder whose workmanship, as demonstrated by the results of air pressure tests on individual welded joints, is below a reasonable standard of quality of consistency in the Engineer's opinion.

(c) Testing of Welded Joints

Where directed by the Engineer welded joints on pipes larger than 675 mm diameter shall be subject to a nitrogen gas test after welding.

A tapped hole (approximately 6 mm diameter) shall be made in the socket end of each pipe by the Contractor and shall be fitted with a suitable non-return valve. Nitrogen, at 400 kPa pressure, shall then be pumped into the annular space between the spigot and socket and the pump disconnected.

If no drop in pressure occurs over the ensuing period of 30 minutes the test shall be deemed to be successful. If the test pressure cannot be maintained for 30 minutes all defects in the weld shall be cut back and rewelded and the test reapplied until successful. The cost of initial and subsequent testing of defective welds shall be at the Contractor's own expense.

The Contractor shall provide all items necessary for the nitrogen tests including compressor, valves, gauges and tubing.

(d) Hydraulic Losses

The frictional losses due to fluid flow in pipe work shall be computed, based on the Hazen- William formula using C=110

a) Valves

The losses in mwc shall be calculated as per empirical formulas k= coefficient shall be taken as under.

k - For sluice valves = 0.2
For butterfly valves = 0.3
For non-return valves = 1.5
For penstocks = as furnished by the manufacturer with documentary evidence.

b) Fittings, specials

For specials like reducers, bell-mouths, tees, elbows, etc, the `k' values shall be as recommended by the British Hydromechanics Research Association (BHRA), Volume 5, in the BHRA fluid Engineering Series.

(e) Pipe work Protection

All underground steel piping shall have their external surfaces protected by application of one coal tar enamel coat, wrapping of fiberglass, one more coat of enamel and a final wrap of enamel impregnated fiberglass. Pipe surface shall be thoroughly cleaned by shot or sand blasting. Primer paint recommended by the enamel manufacturer for the grade of enamel used shall be applied over this cleaned surface within four hours of cleaning. The primer paint shall be thoroughly mixed and applied as recommended by the manufacturer and the coating shall be free of bubbles, globules, drips and runs. The primer shall be thoroughly dry before enamel is applied and the latter shall not be applied later than 3 days after application of primer. First flood coat of enamel shall be overlaid by a single spiral wrap of fiberglass overlapping at least 20 mm on pipe up to 250 mm diameter and 25 mm on larger diameter pipes. Enamel shall be heated slowly in clean kettles, equipped with indicating or recording

thermometers (100°C to 350°C range), to the recommended temperature. The enamel shall be stirred continuously. It shall be seen that fiberglass impregnates in the flood coat. Second coat of enamel and second wrap of bitumen impregnated fiberglass shall be applied in the same way. The total thickness of the coating shall not be less than 2.5 mm. Each end of the pipe left bare for a distance of 150 mm for welding shall be hand coated and wrapped after field welding is completed and hydro tested. Testing of pipe protection shall be done as directed by the Engineer using elcometers, coating thickness guages, and bond test and holiday detectors.

(f) External protection

All underground pipework having a cover less than 1.5 m and more than 4.5 m shall be encased with M 15 concrete of minimum 200 mm thick all around.

All underground pipelines having a cover more than 1.5 m shall be externally protected by guiniting of minimum 40 mm thick as per specification.

All above ground and pipes in galleries shall be externally painted with two coats of epoxy with minimum thickness of 180 microns.

(g) Flexibility in Pipe work

The Contractor shall provide flexibility in the pipe work at joints in the main structures and shall submit proposals for the approval of the Engineer. Flexible joints or collars and cut pipes shall be allowed on all pipe work where necessary to allow for some margin of error in the building work. Wherever possible flexible joints shall be provided (as per Engineer’s directive) with tie bolts or other means to transfer longitudinal thrusts as a whole so that external anchorages may be kept to a minimum. Flexible joints (SS 304 Bellows and Dismantling joints) shall also be provided for case of erection and future dismantling of all valves and Equipment. Particular care shall be taken to ensure that pipe work thrusts are not transmitted to machinery or associated apparatus. The Contractor shall indicate on his detailed drawings what thrust blocks are required.

(h) Puddle Flanges

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting form the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawing and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the Engineer prior approval.

(i) Small Bore Pipes and Hoses

Small bore pipes and hoses shall be of non-flame propagating materials. They shall be arranged for easy dismantling for cleaning where appropriate, and if screwed joint or joints formed by solvent welding are proposed for any chemical line, a sufficient number of flanged or flexible joints shall be provided to enable the pipe work to be removed in sections without working from one end to the other of a particular run. Tees and cocks shall also be provided at convenient points for the connection of a pressure water supply to flush pipe work through as required.

All pipes and hoses shall be labelled to enable individual lines to be identified throughout their run. Racks or trays shall be fixed to the duct walls or walls of tanks and buildings and the chemical pipes shall be fixed to these racks or trays with clips which can easily be removed without dismantling adjacent pipes. The Contract includes for the supply and fixing of all such racks or trays. Full details of the type of hoses, pipes and racks of trays proposed, shall be submitted at the time of tendering.

(j) Support of Pipe work and Accessories

All necessary supports, saddles, slings, fixing bolts and foundation bolts shall be supplied to support the pipe work and its associated equipment in an approved manner. Valve, meters, strainers, and other devices mounted in the pipe work shall be supported independently of the pipes to which they connect.

All brackets or other forms of supports, which can conveniently be so designed, shall be rigidly built up of steel by riveting or welding in preference to the use of castings.

No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Engineer.

After the collars and boxes or other fitting have been fixed in position, the floors, walls and roof structure will be made good by the Contractor.

8.30Cast Iron Pipes

8.45.1 Manufacturing

(a) General

C.I. pipes and fittings shall be systematically checked for any manufacturing defects by experienced supervisors and a very high standard of quality shall be maintained.

Engineer shall at all reasonable times have free access to the place where the pipes and fittings are manufactured for the purpose of examining and testing the pipes and fittings and for witnessing the test and manufacturing.

All tests specified either in this Employer's Requirements or in the relevant Indian Standards shall be performed by the supplier/contractor at his own cost and in presence of the Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes and fittings of that lot. The decision of the Engineer in this matter shall be final and binding of the Contractor and not subject to any arbitration or appeal.

(b) Materials

The general requirements relating to the supply of material shall be as per IS: 1387.

The material for pipes and fittings shall be of good quality cast iron conforming to IS: 210 (Grade -FG 150).

(c) Dimensions

The internal diameter, thickness and length of barrel, dimensions of pipes and fittings shall be as per the relevant tables of IS: 1536/1537/1538 for different class of pipes and fittings.

The tolerances for pipes and fittings regarding dimensions and deviations from straight line in case of pipes shall be as per relevant IS codes.

The standard weight of uncoated pipes and fittings and the permissible tolerance shall be as per relevant IS codes.

(d) Workmanship and Finish

The pipes and fittings shall be stripped, with all precautions necessary to avoid warping or shrinking defects. The pipes and fittings shall be free from defects, other than any unavoidable surface imperfections which result from the method of manufacture and which do not affect the use of the pipes in the opinion of Engineer.

The pipes and fittings shall be such that they could be cut, drilled or machined and may be accepted provided the hardness of the external unmachined surface does not exceed 230 HBS. In the case of spigot and socket pipes and fittings for lead joints, the socket shall be without the centering ring.

In the case of flanged pipes the flanges shall be at the right angles to the axis of the pipe and machined on face. The bolt holes shall be drilled and located symmetrically off the centre line. The bolt hole circle shall be concentric with the bore and bolt holes equally spaced. The flanges shall be integrally cast with the pipes and fittings and the two flanges of the pipe shall be correctly aligned.

(e) Testing

(i) Mechanical Tests

Mechanical tests shall be carried out during manufacture of pipes and fittings as specified in relevant IS codes. The results so obtained shall be considered to represent all the pipes and fittings of different sizes manufactured during that period and the same shall be submitted to the Engineer. The method for tensile tests and the minimum tensile strength requirement for pipes and fittings shall be as per relevant IS codes.

(ii) Brinell Hardness Test

For checking the Brinell hardness, the test shall be carried out on the test ring or bars cut from the pipes used for the ring test and tensile test in accordance with IS 1500.

(iii) Retests

If any test piece representing a lot fails in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same lot. If both the test results satisfy the specified requirements, the lot shall be accepted. Should either of these additional test pieces fail to pass the test, the lot shall be liable for rejection.

(iv) Hydrostatic test

For hydrostatic test at works, the pipes and fittings shall be kept under test pressure as specified in relevant IS codes for 15 seconds, they may be struck moderately with a 700 g hammer. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. The hydrostatic test shall be conducted before coating the pipes and fittings.

(f) Coating

Coating shall not be applied to any pipe and fitting unless its surface is clean, dry and free from rust. All pipes and fittings shall be coated externally and internally with the same material, by dipping in a tar or suitable base bath. The pipe and fitting may be either preheated before dipping or the bath may be uniformly heated. The coating material shall set rapidly with good adherence and shall not scale off. In all instances where the coating material has a tar or similar base, it shall be smooth and tenacious and hard enough not to flow when exposed to a temperature of 65° C, but not so brittle at a temperature of 0^0C as to chip off when scribed lightly with a penknife. In case of pipes and fittings which are imperfectly coated or where the coating does not set or conform to the required quality, the coating shall be removed and the pipes and fittings recoated.

In case the pipes are to be used for conveying potable water, the inside coating shall not contain any constituent soluble in such water or any ingredient which could impart any taste or odour whatsoever to the potable water after disinfection and suitable washing of the mains.

(g) Marking

Each pipe and fitting shall have cast, stamped or indelibly painted on it the following appropriate marks:

i) The nominal diameter.
ii) Flow direction and line marks for installation
iii) Class reference
iv) Mass of pipe
v) Date of manufacture and
vi) Manufacturer's name, initials or identification mark.

Marking shall be done as per relevant IS code.

8.30Jointing

(a) General

Jointing of CI pipes and fittings shall be done as per the requirements of following Employer’s Requirements and as per the relevant IS. After jointing, extraneous material, if any, shall be removed from the inside of the pipe. In case, rubber sealing rings are used for jointing, these shall conform to IS: 5382.

(b) Tyton joints

In jointing cast iron spigot and socket pipes and fittings with tyton flexible joints the contractor shall take into account the manufacture's recommendations as to the methods and equipment to be used in assembling the joints. In particular the contractor shall ensure that the spigot end of the pipe to be jointed is smooth and has been properly chamfered, that the rubber ring as per IS: 5382, is correctly positioned in line, before the joint is made. The rubber rings and any recommended lubricant shall be obtained only through the pipe supplier or as otherwise directed by Engineer.

(c) Flanged Pipes

The gaskets used between flanges of pipes shall be compressed fibre board or natural/synthetic rubber conforming to IS: 638, of thickness between 1.5 to 3 mm. The fibre board shall be impregnated with chemically neutral mineral oil and shall have a smooth and hard surface. Its weight per square metre shall be not less than 112 g/mm thickness.

Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternately. The practice of fully tightening the bolts one after another is highly undesirable. The bolts shall be of mild steel unless otherwise specified.

(d) Cleaning of Pipes and Fittings

The Contractor shall ascertain that each stretch of pipeline is absolutely clear and without any obstruction by means of visual examination of the interior of pipeline suitably lighted by projected sunlight or otherwise. The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipeline, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

(e) Testing at work site

After the pipes and fittings are laid, jointed and the trench partially backfilled except at the joints the stretch of pipe line as directed by Engineer shall be subjected to pressure test and leakage test. Where any section of the pipeline is provided with concrete thrust blocks or anchorages, the pressure test shall not be

made until at least five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorages, the tests shall not be made until atleast two days have elapsed.

Each section of the pipe line shall be slowly filled with water and all air shall be expelled from the pipe by tapping at points of highest elevation before the test is made and plugs inserted after the tests have been completed. The specified test pressure based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe as directed by the Engineer.

The duration of test shall not be less than 5 minutes. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be recaulked until water tight. Any cracked or defective pipes and fittings in consequence of this pressure test shall be removed and replaced by sound material by Contractor at no extra cost to the Engineer and the test shall be repeated to the satisfaction of the Engineer.

After the satisfactory completion of pressure test, the section of pipe line shall be subjected to leakage test. The duration of test shall be 2 hours. No pipe installation shall be accepted until the leakage is less than the number of cm3 /h as determined by the formula:

$$q_L = \frac{ND\sqrt{P}}{3.3}$$

Where,

q_L = The allowable leakage in cm^3/hr
N = Number of joints in the length of the pipeline
D = Diameter in mm, and
P = The average test pressure during the leakage test in Kg/cm^2

Should any test of pipe laid indicate leakage greater than that specified above, the defective joints shall be repaired by Contractor at no extra cost to the Engineer until the leakage is within the specified allowance.

Necessary equipment and water used for testing shall be arranged by Contractor at his own cost. Damage during testing shall be Contractor's responsibility and shall be rectified by him at no extra cost to the Engineer. Water used for testing shall be removed from the pipe and not released in the excavated trenches.

After the tests mentioned above are completed to the satisfaction of the Engineer, the backfilling of trenches shall be done as per the Employer’s Requirements specified elsewhere.

8.30 Un plasticised PVC Pipes and Fittings

Unplasticised polyvinyl chloride pipes, fittings and specials shall be to BS 3505 for potable water and BS 4346: Part 1 for fittings.

The pipes shall be of the spigot and socket type with approved gasket type flexible joint. The rubber gaskets shall be to BS 2494, Class C.

Where PVC pipes, fittings and specials are to be connected to cast iron, stainless steel or steel pipes, all metallic pipes, 'Viking Johnson' type flange adaptors or stepped couplings shall be used.

(a) Polyethylene Pipes

Polyethylene pipes shall comply with BS 6437. The welding method shall be adapted to international standard and contractor shall obtain the approval of the Engineer before proceeding with such works.

(b) Rubber Hosing

Rubber hosing shall conform to BS 5119, Type 2. It shall be capable of handling chlorine and sulphur dioxide solutions at a working pressure of 12 bar.

(c) Copper Tubes and Fittings

Copper tubing and fittings for work above ground level shall comply with BS 2871 and BS 864: Part 2 respectively and be jointed with capillary joints. For underground location the copper pipe shall be to BS 2871: Part 1.

(d) Flanged Joints

All flanges shall comply with BS EN 1092-1/BS 4504. The nominal pressure rating for particular flanges shall be at least equal to the highest pressure rating of the pipes or fittings to which they are attached, but with a minimum nominal pressure of PN 10. All flanges shall be provided with all necessary nuts, bolts, washers and gaskets. In general, valves shall have flanged body ends.

All flanged joints which are buried or in chambers shall be protected with Densomastic and Densotape wrapping, applied in accordance with the manufacturer's instructions.

Flanges shall be installed on the pipes in the factory and field welding of flanges shall only be allowed with the approval of the Engineer.

Where pipework outside pumping stations and surge vessel chambers is catholically protected, an insulated flange shall be incorporated at the first flange inside the structure. These flanges shall be tested to ensure that electrical insulation is achieved.

(e) Gaskets and Joint Rings

Joint rings shall be manufactured to conform with BS 2494 and shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80^{o}C.

Gaskets may be inside the bolt circle type and shall comply with BS 4865: Part 1. Alternatively the gasket shall be to the full diameter of the flange, drilled to suit the appropriate bolt provisions.

Chloroprene rubber with a hardness of 71 to 80 IRHD shall be used.

Joints shall be made in accordance with manufacturer's instructions or as specified herein.

Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark, free from the deleterious effects of heat or cold, and kept flat so as to prevent any part of the rubber being in tension.

Only lubricants recommended by the manufacturer shall be used in connection with rubber rings and these lubricants shall not contain any soluble constituent, shall be suitable for the climatic conditions at the Site and shall contain an approved bactericide.

After cleaning the flanges the gaskets shall be fitted smoothly to the flange and the joint shall be made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made by gradually and evenly tightening bolts in diametrically opposite positions using standard spanners.

Graphite grease shall be applied to the threads of bolts before joints are made.

(f) Flexible Couplings and Flange Adaptors

Flexible couplings and flange adaptors shall be of the Viking Johnson or similar approved pattern and be assembled in accordance with the manufacturer's

instructions and protected, if buried or in chambers with Densomastic and Densotape wrapping applied in accordance with the manufacturers' instructions. Flexible joints shall be harnessed or tied where necessary

8.30 Storage & Shipment

(a) Protection of Pipes and Fittings for Shipment

Except where otherwise specified all items shall have received their complete protective coatings before dispatch from the manufacturer's works and shall be additionally protected by approved means for the period of transit, storage and erection, against corrosion and accidental damage.

For the protection of pipe linings and in particular for protecting cement mortar linings from drying out, protective metal or timber discs shall be fitted over the ends of pipes and fittings. Similar timber protective discs shall be attached to all flanges of pipes and fittings, by means of bolts specifically provided for the purpose and which shall be discarded when the item is incorporated in the Works. The sleeves and flanges of flexible joints shall be wired together in suitable bundles.

(b) Storage of Pipeline Materials

Pipes and fittings shall be stored raised off the ground, and shall be carefully supported, cushioned and wedged. Pipes shall not rest directly on one another and shall not be stacked more than four pipes high or two pipes high in the case of pipes of 500 mm diameter or over. Special care shall be taken to ensure that flexible pipes are cradled and supported in a manner that prevents any distortion of the pipes.

Couplings and joints (and all components thereof) and other similar items shall be stored in dry conditions, raised from the ground in sheds or covered areas.

Storage areas shall be carefully set out to facilitate unloading, and checking of materials with different consignments stacked or stored separately with identification marks clearly visible.

Where items to be stored have a limited shelf life or require special storage arrangements, the method of storage shall be to the approval of the Engineer and in accordance with the manufacturer's instructions.

All pipes and fittings supplied as spares shall have end covers which are proof against the entry of sand and vermin. Mortar lined pipes and fittings shall have

end covers which form a complete seal, provision being made to accommodate the effects of temperature changes. Pipes and fittings supplied as spares shall have a temporary white external finish and shall be stored sheltered from the direct rays of the sun.

End covers and protection shall not be removed until incorporation of the pipes and fittings into the Works.

8.30Transportation of Pipes and Fittings

Any vehicle on which pipes are transported shall have a body of such length that the pipes do not overhang. Large pipes shall be placed on cradles and the loads properly secured during transit. The pipes shall be handled in accordance with the manufacturer's recommendations.

Approved slings shall be used and all hooks and dogs and other metal devices shall be well padded. Hooks engaged on the inner wall surface at pipe ends shall not be used. Steadying ropes shall be employed. The positions of lifting slings shall ensure that stresses and tendency towards deformation in the pipes are kept at a minimum.

Pipe handling equipment shall be maintained in good repair and any equipment which in the opinion of the Engineer may cause damage to the pipes shall be discarded.

Under no circumstances shall pipes be dropped, be allowed to strike one other, be rolled freely or dragged along the ground.

8.30Inspection of Pipes and Fittings

Before incorporating into the Works each pipe shall be brushed out and carefully examined for soundness. Damaged pipes which in the opinion of the Engineer cannot be satisfactorily repaired shall be rejected and removed from Site.

Damage to pipe coatings or linings shall be repaired to the satisfaction of the Engineer.

Built-in Pipe work and other Plant

The pipes and other Plant in water retaining structures shall, wherever possible, be built in as the work on the structure proceeds. The Contractor shall ensure that delivery of the requisite pipe work and other Plant is in accordance with the requirements of the programme.

Where a pipe subject to thrust passes through a concrete structure or where an external seal is required, a puddle flange shall be used. The puddle flange dimensions shall be to BS EN 1092-1/BS 4504 but shall be undrilled. The exterior of the pipe shall be cement washed symmetrically about the puddle flange by the manufacturer for a length at least equivalent to the thickness of the wall through which it passes.

The Contractor shall be responsible through every stage of the Works for checking the correctness of the setting of built-in Plant and shall satisfy himself they are positioned in accordance with his approved drawings.

8.30Pipe laying

(a) Carting & Handling

Pipes and fittings /specials shall be transported from the factory to the work sites at places along the alignment of pipeline as directed by the Engineer. Contractor shall be responsible for the safety of pipes and fittings/specials in transit, loading/unloading. Every care shall be exercised in handling pipes and fittings/specials to avoid damage. While unloading, the pipes and fittings/specials shall not be thrown down from the truck on to hard surfaces. They should be unloaded on timber skids with steadying ropes or by any other approved means. Padding shall be provided between coated pipes, fittings/specials and timber skids to avoid damage to the coating. Suitable gaps between pipes should be left at intervals in order to permit access from one side to other. In case of spigot socket pipes, care should be taken regarding orientation of pipes while unloading. As far as possible pipes shall be unloaded on one side of the trench only. The pipes shall be checked for any visible damage (such as broken edges, cracking or spalling of pipe) while unloading and shall be sorted out for reclamation. Any pipe which shows sufficient damage to preclude it from being used shall be discarded. Dragging of pipes and fittings/specials along concrete and similar pavement with hard surfaces shall be prohibited.

(b) Storage

Each stack of pipes shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers wherever possible. Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom layer to keep the stack stable. The stack shall be in pyramid shape or the pipes laid lengthwise and crosswise in alternate layers. The pyramid stack shall be made for smaller diameter pipes for conserving space in storing them. The height of the stock shall not exceed 1.5 m.

Fittings/Specials shall be stacked under cover and separated from pipes.

Rubber rings shall be stored in a clean, cool store away from windows, boiler, electrical equipment and petrol, oils or other chemicals. Particularly in the field where the rubber rings are being used it is desirable that they are not left out on the ground in the sun or overnight under heavy frost or snow conditions.

8.52 Laying

(a) Excavation

Before excavating the trench, the alignment of pipeline shall be approved by the Engineer. The excavation of trenches and pits for manholes/ chambers shall be carried out in accordance with the Employer's Requirements described elsewhere and shall be done such that it does not get far ahead of the laying operation as approved by the Engineer.

To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, red lanterns and guards as required shall be placed and maintained during the progress of the construction work and until it is safe for the traffic to use the roadways. The relevant Indian Standards and the rules and regulations of local authorities in regards to safety provisions shall be observed.

Suitable fencing shall be provided along the sides of trenches and pits. The posts of fencing shall be of timber securely fixed in the ground not more than 3 m apart and they shall not be less than 75 mm in diameter or less than 1.2m above surface of the ground. There shall be two rails, one near the top of the post and the other about 450mm above the ground and each shall be from 50mm to 70mm in diameter and sufficiently long to run from post to post to which they shall be bound with strong rope. The method of projecting rails beyond the post and tying them together where they meet will not be allowed on any account. All along the edges of the excavation trenches a bank of earth about 1.2 m high shall be formed where required by the Engineer for further protection.

The road metal and also the rubble packing shall first be stripped off for the whole width of the trench/pit and separately deposited in such place or places as may be determined by the Engineer.

During excavation, large stones and rubble shall be separated and removed from the excavated soil and stacked separately. The material from excavation shall be deposited on either side of the trench leaving adequate clear distance from the edges of the trench and pit, or as may be necessary to prevent the sides of the trench pit to slip or fall, or at such a distance and in such a manner as to avoid

covering fire hydrants, sluice valves, manholes and covers etc. and so as to avoid abutting the wall or structure or causing inconvenience to the public and other service organizations or otherwise as the Engineer may direct.

Contractor shall take into account additional excavation if any as the Engineer may require in order locating the position of water pipes, drains, sewers etc. or any other works which may be met with, in or about the excavation of trenches/pits while quoting the rates for excavation of trenches /pits while quoting the rates of excavation. Such service lines if met with during excavation shall be properly maintained by Contractor, by means of shoring, strutting, planking over, padding or otherwise as the Engineer may direct, and shall be protected by the Contractor from damage during the progress of the work. All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structure /pipe line of water, gas, sewage etc.

Utmost care shall be taken to see that the width of the trench at the top of pipe is not more than the minimum requirement. In case additional width is required it shall be provided only in the top portion from the ground level upto 300 mm above the top of pipe. If any extra width is provided in the area below this portion, Contractor shall have to provide remedial measures in the form of lime concrete or rubble masonry otherwise at the discretion and to the satisfaction of the Engineer. If rock is met with, it shall be removed to 15 cm below the bottom of pipes and fittings/specials and the space resulting shall be refilled with granular materials and properly consolidated. Bottom of trenches/pits shall be saturated with water well rammed wherever the Engineer may consider it necessary to do so.

Wherever a socket or collar of pipe or fitting/ special occurs, a grip is to be cut in the bottom of the trench or concrete bed to a depth of at least 75 mm below the bed of the pipe so that the pipe may have a fair bearing on its shaft and does not rest upon its socket. Such grip shall be of sufficient size in every respect to admit the hand all around the socket in order to make the joint and the grip shall be maintained clear until the joint has been approved by the Engineer.

When welding is to be carried out with the pipes and specials in the trench, additional excavation of not more than 60cm in depth and 90 cm in length shall be made at joints in order to facilitate welding.

The excess excavated material shall be carried away from site of works to a place up to a distance as directed by the Engineer. This shall be done immediately so as not to cause any inconvenience to the public or traffic. If the instructions from Engineer are not implemented within seven days from the date of instructions to

cart the materials and to clear the site, the same shall be carried out by the Engineer and any claim or dispute shall not be entertained in this respect.

(b) Dewatering

During the excavation, if subsoil water is met with Contractor shall provide necessary equipment and labourers for dewatering the trenches. The Contractor shall also make necessary arrangement for the disposal of drained water to nearby storm water drain or in a pit if allowed by the Engineer. In no case the water shall be allowed to spread over the adjoining area. Before discharging this water into public sewer/drain, the Contractor shall take necessary permission from the local authorities.

(c) Special Foundation in Poor Soil

Where the bottom of the trench and sub grade is found to consist of material which is unstable to such a degree that in the opinion of the Engineer, it cannot be removed and replaced with an approved material thoroughly compacted in place to support the pipe properly, a suitable foundation for the pipes, consisting of piling, timbers or other materials, in accordance with relevant drawings to be prepared by the Contractor and as instructed by the Engineer shall be constructed.

(d) Wooden Shoring

Contractor shall suitably design polling boards, waling and struts to meet different soil conditions that might be encountered in excavating trenches/pits. The horizontal and vertical spacing of struts shall be such that not only the sides of trenches shall be prevented from collapse but also easy lowering of pipe in trenches shall be ensured without creating undue obstructions for the excavation of the work. Any inconvenience and/or delay that might be caused in lowering pipes in trenches as a result of adopting improper spacing of struts by Contractor shall be his sole responsibility. No part of shoring shall at any time be removed by Contractor without obtaining permission from the Engineer. While taking out shoring planks the hollows of any form must simultaneously be filled in with soft earth well rammed with rammers and with water.

The Engineer may order portions of shoring to be left in the trenches /pits at such places, where it is found absolutely necessary to do so to avoid any damage which may be caused to buildings, cables, gas mains, water mains, sewers etc. in close proximity of the excavation, by pulling out the shoring from the excavations. The Contractor shall not claim, on any reason whatsoever, for the shoring which may have been left in by him at his own discretion.

(e) Steel Plate Shoring

Where the subsoil conditions are expected to be of a soft and unstable character in trench/pit excavation, the normal method of timbering may prove insufficient to avoid subsidence of the adjoining road surfaces and other services. In such circumstances, the Contractor will be required to use steel trench sheeting or sheet piling adequately supported by timber struts, waling etc., as per the instructions, manner and method directed by the Engineer. Contractor shall supply pitch, drive and subsequently remove trench sheeting or piling in accordance with other items of the Employer's Requirements.

(f) Boning Staves and Sight Rails

In laying the pipes and fittings/ specials the centre for each manhole / chamber or pipeline shall be marked by a peg. Contractor shall dig holes for and set up two posts (about 100 x 100 x 1800 mm) at each manhole/chamber or junction of pipelines at nearly equal distance from the peg and at sufficient distances there from to be well clear of all intended excavation, so arranged that a sight rail when fixed at a certain level against the post shall cross the centre line of the manhole/chamber or pipe lines. The sight rail shall not in any case be more than 30 m apart; intermediate rails shall be put up if directed by the Engineer.

Boning staves of 75 mm x 50 mm size shall be prepared by Contractor in various lengths, each length being of a certain whole number of meters and with a fixed tee head and fixed intermediate cross pieces, each about 300 mm long. The top-edge of the cross piece must be fixed below the top-edge of the tee-head at a distance equal to the outside diameter of the pipe or the thickness of the concrete bed to be laid as the case may be. The top of cross pieces shall indicate different levels such as excavation for pipe line, top of concrete bed, top of the pipe etc. as the case may be.

The sight rail of size 250 mm x 40 mm shall be screwed with the top edge resting against the level marks. The center line of the pipe shall be marked on the rail and this mark shall denote also the meeting point of the center lines of any converging pipes. A line drawn from the top edge of one rail to the top edge of the next rail shall be vertically parallel with the bed of the pipe, and the depth of the bed of pipe at any intermediate point may be determined by letting down the selected boning staff until the tee head comes in the line of sight from rail to rail.

The post and rails shall be perfectly square and planed smooth on all sides and edges. The rails shall be painted white on both sides, and the tee-heads and cross-piece of the boning staves shall be painted black.

For the pipes converging to a manhole/chamber at various levels, there shall be a rail fixed for every different level. When a rail comes within 0.60 M of the surface of the ground, a higher sight-rail shall be fixed for use with the rail over the next point.

The posts and rails shall in no case be removed until the trench is excavated, the pipes are laid and the Engineer gives permission to proceed with the backfilling.

(g) Laying of Pipes and Fittings/Specials

All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structure/pipeline of water, gas, sewage etc. After excavation of trenches, pipes shall not be lowered unless the dimensions of trenches and bedding work for pipes at the bottom of the trenches are approved and measured by Employer /Engineer. Pipes and fittings/specials shall be carefully lowered in the trenches. Special arrangements such as cranes, tripods with chain pulley block for lowering the pipes and fittings/specials shall be made by Contractor. In no case pipes and fittings/specials shall be dropped. Slings of canvas or equally non-abrasive material of suitable width or special attachment to fit the ends of pipes and fittings/specials shall be used to lift and lower the coated pipes and fittings/specials. The pipes and fittings /specials shall be inspected for defects and be rung with a light hammer preferably while suspended to detect cracks. If doubt persists, further confirmation shall be done by pouring a little kerosene/dye on the inside of the pipe at the suspected spot. No sign of kerosene/dye should appear on the outside surface. Pipes and fittings/specials damaged during lowering or aligning shall be rejected by the Engineer.

All the pipes are to be laid perfectly true both in alignment and to gradient specified. In case of spigot and socket pipe the socket end of the pipe shall face upstream, except when the pipeline runs uphill in which case the socket ends should face the upgrade. The laying of pipes shall always proceed upgrade of a slope. After placing a pipe in the trench, the spigot end shall be centered in the socket and the pipe forced home and aligned to required gradient. The pipes shall be secured in place with approved backfill material tamped under it except at the socket. Pipes and fittings/specials which do not allow a sufficient and uniform space for joints shall be removed and replaced with pipes and fittings/specials of proper dimensions to ensure such uniform space. Precautions shall be taken to prevent dirt from entering the jointing space. At times when pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the Engineer. During the period that the plug is on, the Contractor shall take proper precautions against floating of the pipe owing to entry of water into the trench. Wherever it is necessary to deflect pipe from a straight line, either in the vertical or horizontal plane, to avoid obstructions or

where long radius curves are permitted the deflection allowed at joints shall not exceed 2 ½0. In case of pipes, with joint to be made with loose collars, the collars shall be slipped on before the next pipe is laid. The pipes shall be laid such that the marking on pipes appears at the top of the pipes.

The cutting of pipe for inserting valves, fittings, or specials shall be done in a neat and workman like manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. For this purpose, pipe cutting machine shall be used.

(h) Thrust Blocks

Thrust Blocks shall be provided for all piping works, to counteract hydraulic thrust, at places wherever directed by the Engineer as per approved design.

(i) Jointing

Jointing for pipes and fittings/specials shall be done in accordance with the relevant Employer's Requirements depending upon the type of pipes being used.

(j) Testing and Commissioning

Testing and commissioning of pipes shall be done in accordance with the relevant Employer's Requirements.

(k) Backfilling

Trenches shall be backfilled with approved selected excavated material only after the successful testing of the pipeline. The tamping around the pipe shall be done by hand or other hand-operated mechanical means. The water content of the soil shall be as near the optimum moisture content as possible. Filling of the trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressure does not occur. Backfilling shall be done in layers not exceeding 30 cm. Each layer shall be consolidated by watering, ramming, care bring taken to avoid damage to the pipeline. In case of the mild steel pipes/specials, the spiders provided during assembly and welding shall be retained until the trench is refilled and consolidated. Where timbers are placed under the pipeline to aid alignment, these timbers shall be removed before backfilling.

The Contractor is requested to provide the method of Backfilling compaction test and evaluation value and obtain the approval from the Engineer.

(l) Reinstatement of Road/Footpath

Reinstatement of road/footpath shall be done as per the requirements of local authorities and the Employer's Requirements after completion of work.

(m) Clearing of Site

All surplus materials, and all tools and temporary structures shall be removed from the site as directed by the Engineer and the construction site left clean to the satisfaction of the Engineer.

8.53 UV Disinfection

General Design

Where Installations employ an open-channel design, the channel design shall ensure exposure of all elements of the effluent flow to the UV radiation. Flow through the system shall ideally be 'plug flow' and the presence of 'dead areas' and 'short-circuiting' of flows shall be avoided. However, upstream baffle plates or flow straighteners shall not be used as they are subject to blinding and their absence has been demonstrated to make no difference to the removal of bacteria.

At the design stage of larger systems, the designer shall calculate the operating cost for different arrangements e.g. single channel or dual channel, and take this into account when making design decisions. Different arrangements have different numbers of lamps on permanently and so will have different operating costs.

The design of the Channel and the associated channels or pipework shall not allow the Channel to empty due to process malfunction, either back into the process or forward via the moving penstock (if fitted).The design of the channel and any level control system shall ensure that the lamps are adequately submerged through all flow conditions.

Upstream processes and plants shall be designed such that sufficient flow is maintained on the UV plant to prevent lamps overheating and baking deposits on the lamp envelope.

The level control system shall avoid rapid changes of level in the Channel. The installation shall ensure adequate surrounding space to permit safe and unhindered maintenance access.

Lamp modules shall be easily and safely removed and replaced by one person, with appropriate lifting equipment provided if necessary (mandatory if more than 25kg). Lifting equipment may use an electric hoist, a davit arrangement or any other suitable system. Manual chain hoists are not acceptable as the chains frequently break the lamps.

The contractor shall confirm their proposed dose rate to achieve the disinfection requirements under the contract and provide supporting calculations and references to justify their selection. The selected UV equipment shall be validated to achieve the proposed UV dose rate and certified by Deutscher Verein des Gas- und Wasserfaches (DVGW) or United States Environmental Protection Agency (USEPA).

Channel Draining and Cleaning

For maintenance purposes it shall be possible to manually isolate and drain channels if necessary. Above-ground channels shall have a drain valve at each end (50 or 75mm bore depending on the channel size) piped to the works drain. Below-ground concrete channels shall have a sump at the lowest point in the channel for use with a submersible pump in order to drain the channel. Provision shall be made for a suitable discharge point for the pump.

Systems shall be provided or methods adopted to ensure that it is possible to clean any UV channel, without breaching discharge consents. This may involve utilisation of

upstream storage, provision of cleaning mechanisms, provision of parallel channels or other methods agreed with the Employer.

Sampling

Provision shall be made for taking effluent samples upstream and downstream of the disinfection system. The sampling points shall be fully shielded to prevent exposing operators to UV radiation. Any sampling apertures shall have an opening not less than 450 mm in any dimension to permit the use of a 10 litre sampling vessel. The downstream sampling point must be immediately downstream of the UV channel discharge weir to ensure adequate mixing of the sample.

Foam and Bubbles

This design of the UV plant and upstream processes shall prevent the generation and incorporation of foam or entrained air bubbles, which might impair the UV transmittance. If required this shall include the construction of surface baffles to prevent foam ingress, and stilling chambers to calm flows and allow air to escape before entering the UV channel.

Multi-Channel Systems

On UV plants where the flow is split between more than one channel, each channel shall be hydraulically separate from all the others, such that changes in level in one channel do not cause changes in level or flow in any other. Level control systems if required shall be independent for each channel. Two channel systems shall normally operate with both channels active. Provision shall be made for individual channels to be isolated and drained for maintenance and cleaning.

Lamp Cleaning

An automatic lamp cleaning (in-place) system shall be incorporated within the disinfection system design, using the most effective wiper materials available. This system shall ensure that all lamps (in-use or standby) are regularly cleaned to prevent build-up of scale, fouling or other deposits which would otherwise impair the efficiency of the installation.

The system shall be capable of meeting effluent standards under conditions of full-flow operation while a cleaning cycle is in progress.

Off-line acid bath cleaning is acceptable. A safe means of diluting or neutralising any acid or caustic cleaning chemicals shall be provided prior to disposal into the wastewater process stream.

Any cleaning chemicals provided or specified for use with the system shall be free from toxic effects on the wastewater treatment system and shall be readily degraded or diluted within the wastewater treatment system to prevent harm to the environment or compromise the discharge consent through contamination of the final effluent with any dangerous substances present as trace components of the spent cleaning solution.

It shall be possible to dispose of such chemicals into the wastewater treatment process without disruption to that process. Information on such chemicals must be available on site with usage and handling instructions available to employees.

Flow Measurement

Each channel or reactor shall be provided with an independent flow measuring system. Addition or removal of flow between the point of measurement and the UV plant is not permitted.

Transmittance Measurement

Transmittance shall be measured with a continuously reading on-line monitor. Continuous cleaning shall be provided for the monitor using the most effective wiper materials available.

Level Control

Channel or Reactor design and level controls shall ensure optimum lamp submergence under all flow conditions

Lamp Control

The system energy output shall be automatically controlled to match the UV dose rate to the final effluent flow rate; e.g. by switching lamp banks in or out of service or by varying the power output on variable power systems. (Flow balancing might be required to avoid excessively short cycle times.

The selection of duty and boost lamp banks shall be rotated to ensure equal use of all lamps and prevent bio film growth on lamps remaining unused for prolonged periods. Lamps to be wiped even when they are not running.

The control system shall include measures to recognise and record lamps out of service through maintenance or failure and make suitable allowance for UV output energy reduction as the lamps age, thus ensuring maintenance of the correct dose.

If the dose rate is controlled by measurement of effluent transmittance, lamp intensity, flow or any other measurement, then upon any failure of any such system the plant shall revert to “full power mode”. In “full power mode” the number of lamp banks required to achieve the applied dose at consented transmittance and full flow shall be activated in the affected channel.

Health and Safety

UV lamps shall be fully enclosed, shielded or provided with covers such that no personnel can be exposed to UV radiation from the installation. Covers or removable protection shall have fail-safe interlocking for the lamp power supplies to isolate lamps before removing the protective covers such that no exposed lamps can be illuminated and no UV radiation can escape from the installation.

Blanking covers shall be provided to prevent the escape of stray radiation if any lamps or modules are removed from the system for maintenance. These covers shall be interlocked with the electrical power supply to isolate relevant sections when removed.

Any chemical cleaning system or chemical storage for such a system shall be provided with all necessary safety and containment systems as defined by legislation.

Lifting equipment shall be provided for all removable items exceeding 25 kg in weight and for lighter loads if there is poor posture, limited space or other significant risk.

The system shall be designed to minimise the possibility of mercury spillage through lamp breakage. Spent or failed lamps shall be disposed of safely at a regulated disposal facility.

End of Part 8